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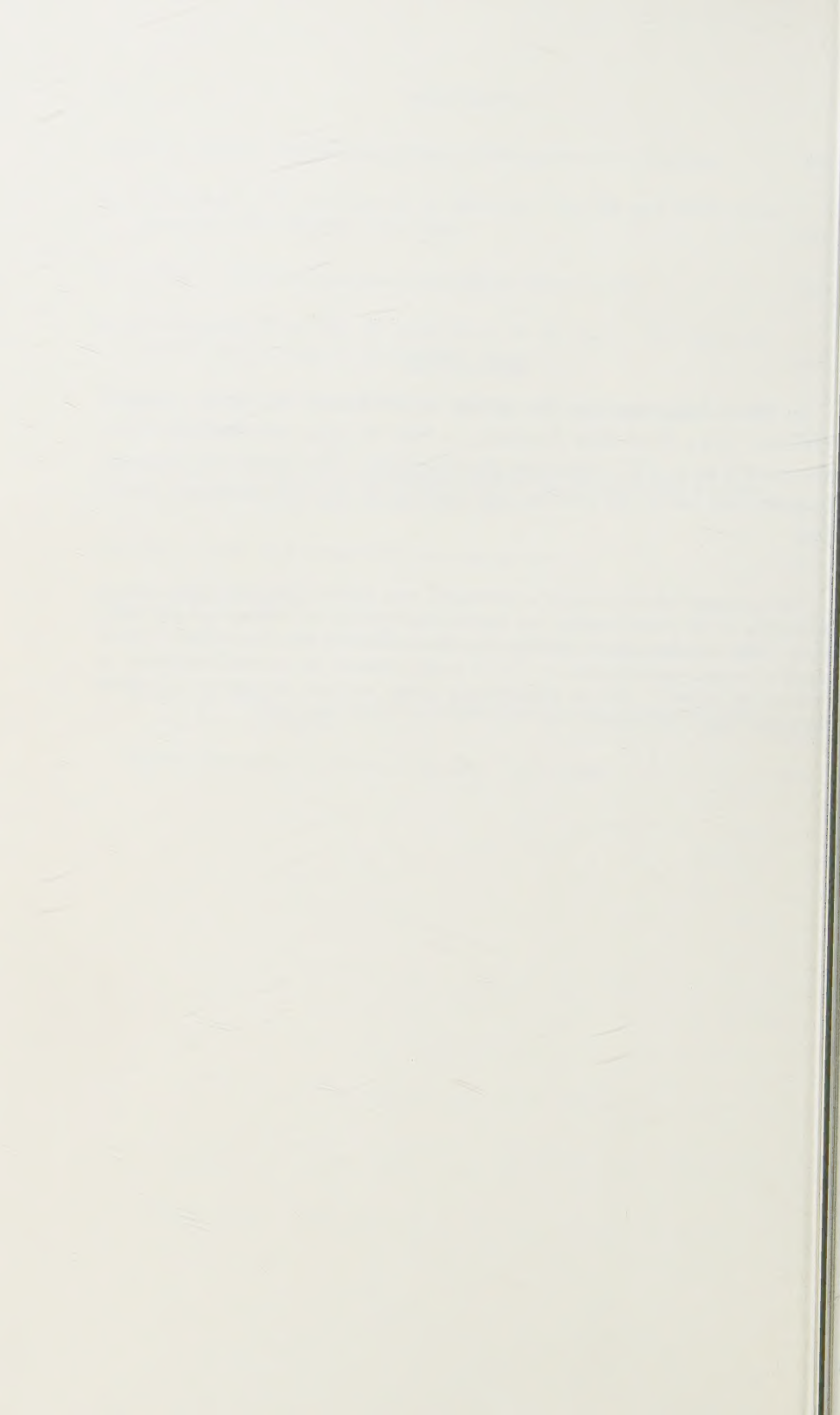
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## ERRATUM

In "Sex differences in the pelves of Primates" by A. H. Schultz (in vol. 7, no. 3 of this Journal), a line of type was omitted from footnote 6 on p. 417, following the third line. The corrected footnote is reprinted below for cutting and pasting in over the incorrect printing.

<sup>6</sup> In macaques labor is usually a prolonged, very difficult and exhausting process according to the many detailed and careful observations of Tinklepaugh and Hartman ('30). In chimpanzees, on the other hand, Yerkes ('43) found that: "Birth usually occurs expeditiously . . . It is rarely difficult or seriously injurious to mother or infant." Of an exceptionally large newborn chimpanzee, weighing 1900 gm, Egg ('45) reports that its birth was "quick and easy."





# THE PREDATORY IMPLEMENTAL TECHNIQUE OF AUSTRALOPITHECUS

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FORTY FIGURES

The terrestrialized human precursors, who adopted bipedal in preference to quadrupedal postural habits, were forced simultaneously to rely upon their hands instead of fangs for assault and repulse. The inevitable result of the absence of long tearing canines and shearing premolars (or the presence of stubbed canines and grinding premolars) in the advanced anthropoid is aggressive hands. This correlation was recognized by Darwin (1871) when he said "as they [the early male forefathers of man] gradually acquired the habit of using stones, clubs or other weapons for fighting with their enemies or rivals they would use their jaws and teeth less and less. In this case the jaws, together with the teeth, would become reduced in size, as we may feel almost sure from innumerable analogous cases."

Trotter ('19) has probably summarized in the most succinct fashion the far-reaching structural implications of such primate postural divergence:

"The upright posture changes the whole mechanics of attack and defence from that of the quadruped. The head is withdrawn from the front of the animal and thus being no longer available as a foundation for offensive and defensive structures, the cranium is at last and finally safe from them . . . limitation in the movements of the mandible necessarily ensued. With a poised instead of a slung skull, the mouth can

no longer be opened freely enough for the aggressive use of fangs. Thereupon the cranium is no longer called upon to find attachment for the correspondingly massive muscles."

The doubts that some scientists previously expressed about the erectness claimed for *Australopithecus* have been removed by more recent discoveries of adult skulls and limb-bone fragments. It is now generally recognized, as Le Gros Clark ('47, p. 393) puts it that:

"They were hominoids of small stature (probably similar in this respect to the pygmy races of present-day mankind), with brains not much larger relatively than those of the gorilla and chimpanzee, massive jaws showing many human features, a dentition fundamentally of human type . . . and limbs approximating in their structure and proportions to those of the Hominidae. They were evidently capable of standing and walking with an almost erect posture, and the hands and feet were relatively small and delicately built."

Since these words were written the innominate bone found at Sterkfontein and the occiput from Makapansgat have provided further evidence that these creatures are more closely related to man than they are to the apes. They are proto-human beings; and they are the most primitive hominids of whom we have knowledge. It therefore becomes correspondingly urgent that we should elicit from those deposits in which proto-humans occur all the available information bearing on their manual dexterity and implemental intelligence.

I contended ('26) that *Australopithecus* was a hunter of game, and the cavern breccia a midden-heap; and that its contents (consisting of the comminuted bones of turtles, birds, insectivores, rodents, baboons and small buck as well as shells of birds' eggs), indicated by its nature, its sparsity and its searched-over and exhausted character, the careful and thorough picking of an animal, which did not live to kill large animals but killed small animals to live. Later, crabs and rock-rabbits were added to the earlier list of dietetic delicacies found at Taungs. In a description of the dentition of *Australopithecus* (Dart, '34), it was shown that the skulls of the

Taungs baboons belonged to animals that had been killed by dexterous force. Some skulls showed radiating fractures due to the impact of sharp objects, probably stones, in the right parieto-temporal region of the skull and fractures of "contre-coup" nature such as occur in human skulls that have been struck violently. Others exhibited rounded openings in the vertex or base suggesting that their contents were forcibly removed for food.

In the memoir on the Australopithecinae, published jointly with Schepers, Broom ('46) agreed with the opinion expressed about Taungs and the hunting ability of *Australopithecus africanus* because all the baboon skulls he had seen had depressed fractures on top of the head and "most of these fractures could only have been produced by a blow from a stick or stone." Having seen some of the Taungs baboon skulls during his 1946-47 visit to South Africa, Le Gros Clark expressed the opinion that not enough attention had been paid to this subject and suggested that all the baboon material from australopithecoid sites be statistically examined for evidence of intentional violence, in order to see to what extent the Taungs material was typical, and how far the manipulation of tools was customary in the Australopithecinae.

The presence of *Parapapio broomi* and *Australopithecus prometheus* in the limestone breccia at the Limeworks Cavern of Makapansgat Valley near Potgietersrust in the Central Transvaal, has demonstrated (Dart, '48) that the kitchen-midden deposits there (attributed by me in 1926 to primitive man because of the presence of fire-charred bones) are coeval with those of Sterkfontein.

With the kind assistance of the Directors of the South African Museum in Cape Town and of the Transvaal Museum in Pretoria, and also of Dr. Robert Broom, I therefore assembled all the available baboon material from Taungs, Sterkfontein and Makapansgat for analysis during 1947. None of these three man-ape cavern deposits has yet produced intentionally fashioned stone implements, which might betray the presence of implement-fashioning man; nor do they reveal

that the man-apes themselves deliberately fashioned stone tools. All of them have however yielded baboon skulls which I hope to show, with more precision than previously, belonged to animals that for the most part became fossilized after succumbing to lethal localized blows. It is the purpose of this paper therefore to place on record a detailed inventory of these skulls together with a brief description of their general appearance and of the damage inflicted upon them prior to fossilization, and also a provisional diagnosis of the impacts responsible for the damage.

#### MATERIAL

The available specimens comprised 58 baboon skulls, endocranial casts, and jaw or calvarial fragments, as follows: from Taungs 21, from Sterkfontein 22, and from Makapansgat Valley limeworks 15. In addition there were 6 skulls or endocranial casts of the Australopithecinae themselves.

The material is therefore adequate both locally and collectively for the determination of the issues involved. The museum provenance of each specimen has been indicated for the sake of future reference by the use of the following abbreviations: *Ct.*, South African Museum, Capetown; *Tvl.*, Transvaal Museum, Pretoria; *A.D.*, Anatomy Department, University of the Witwatersrand; *B.P.I.*, Bernard Price Institute of Palaeontology, University of the Witwatersrand.

As no deliberate attempt had been made previously to display clearly the pre-fossilizational damage done to these skulls, it was soon apparent that further development of the fossils would make the specimens more demonstrative. This work was handed over to Messrs. E. W. Williams and A. R. Hughes of the Anatomy Department and in the end devolved especially upon Mr. Hughes, who is to be congratulated on the skill he exercised in developing the fossils. This procedure was also responsible incidentally for disclosing several additional fossils hidden in the breccia, as well as further unexpected evidence of the sort for which we were especially enquiring.



## GENERAL CONSIDERATIONS

Reassembling the Taungs specimens has enabled Drs. L. H. Wells, J. H. S. Gear and myself to confer about their zoological status (as well as pre-fossilizational damage they suffered) with the result that, as the protocols show, 12 of the Taungs specimens have now been referred to the species *Parapapio africanus* Gear, and 8 to the species *Parapapio izodi* Gear.

In examining the baboon skulls and available endocranial casts from Taungs, Sterkfontein and Makapansgat Valley, I have not only had the advantage of checking the specimens over personally but have profited by the critical views expressed by numerous people, who were qualified by their medical and anthropological experience to give competent opinions upon the matters at issue. Chief amongst these of course, has been Professor R. H. Mackintosh, the Head of the Department of Forensic Medicine in this University, who has had a life-long experience with, and has made a special study of, cranial injuries inflicted by lethal implements.

This examination and consultation has shown that out of more than 50 baboons from these three sites approximately 80% exhibit evidence of having been subjected to purposeful violence, that could only have been inflicted by implements held in hands or by the crushing hands themselves. Not only the skulls of baboons but also most of the adult specimens of the australopithecine group represented by skulls or endocranial casts, exhibit depressed fractures. Thus the endocranial cast of *Plesianthropus transvaalensis* type 1, although tolerably complete, was associated with a crushed skull. The second *Plesianthropus* or type 2, and the third or type 3, endocranial casts of the same Sterkfontein species were also distorted (see figs. 25 and 26). More dramatically still, the breccia overlying the *Paranthropus robustus* skull contained the actual piece of stone, about 2 inches in diameter, which had apparently driven the parietal bone ahead of it down from the roof into the floor of the endocranial cavity (see fig. 27). Schepers, who extracted the flint-like rock piecemeal, said ('46):

“The presence of this rock is evidence suggestive of the claims that have been previously made that the Homunculi represented by the Australopithecoid and Plesianthropoid fossils were skilled enough to employ missiles or weapons for defensive, offensive and predatory purposes. It is certainly remarkable that both the *Plesianthropus endocranial cast type 2* and the *Paranthropus* specimen bear evidence of depressed fractures of the calvarial vault.”

Schepers then discussed the possibility of attributing these deformities to rockfalls or the settling of the deposits; but pointed out that “settling floor deposits, would either slowly warp the respective bones and distort the whole skull, or would be referred to the suture lines, which would tend to be prized apart in a completely desiccated skull. A rockfall on an exposed skull . . . will probably result in a complete splintering of the skull.”

The customary, and often uncritical, attitude expressed towards damaged bones recovered from cavern deposits is to attribute the damage (a) carnivora or (b) falls of rock or earth. Relative to carnivora, it is well known that most South African carnivora, such as the lion, jackal and spotted hyaena, actually avoid caverns and live out on the veld, killing their prey and consuming it in open country. Two South African types, namely the leopard and the brown hyaena, are attracted by the protection of rock shelters or fissures, and the leopard customarily preys on baboons.

But it has never been shown, as far as I am aware, that either the leopard or the brown hyaena could accumulate in a fissure or in cavern deposits of the dimensions laid bare at Makapansgat, where they extend to hundreds and even thousands of cubic feet. This year alone we have taken away from the Makapansgat dump more than 10 tons of bone breccia sorted out of approximately 600 tons of dumped material; and at least another 1000 tons still remain to be sorted. Even if these two carnivora had made such extensive localized accumulations, it would still remain to be demonstrated that the brown hyaena (or the leopard) was a systematic slayer of other

carnivora and would collect the bones of other leopards as well as those of the jackal and lion, that have been found there; or would drag into the deposit remains of the largest ungulates such as the kudu, giraffe, hippopotamus and rhinoceros; and could also kill the elephant.

With regard to the second facile assumption, that falls of rock or subsidences of earth might be responsible, Professor Mackintosh (who has frequently conducted meticulous post mortems in Johannesburg upon human bodies fatally overwhelmed in collapses of earth or rock), has borne out Schepers' remarks by informing me that such crushing is quite distinctive. Being unselective in their application and general in their effects, earth collapses or rock falls crush the whole pelvis, thorax, or head, or distort the entire body. These skulls on the contrary consistently display damage that is sharply localized. In many instances the depressed areas are so specific that the direction from which the blow was delivered can be reasonably inferred and the type of weapon responsible for the fracture diagnosed, as is so frequently done for recent human injuries by medico-legal experts. Such implemental injuries, needless to say, are also incapable of being inflicted by the teeth or paws of carnivora (see illustrations) but present features characteristic or distinctive of the implement employed.

#### THE FRAGILITY OF THE BABOON SKULL

The weakest region of the human skull is the base, and more especially the speno-orbital junctural region between the neural and the visceral cranium. Consequently, when a human skull is subjected to severe localized impacts of extraneous origin, the concussion is apt to cause a shattering of the *base* in this situation and a springing of the various cranial sutures according to the direction in which the applied force happens to be propagated.

Man's skull is better adapted by its globular form than the more flimsy skull of the baboon to resist external impacts, by diverting the force of a truncheon tangentially or dispersing

it widely. The hourglass form of the baboon skull, on the other hand, is most inappropriately constructed for resisting a localized blow from a club of any sort. The massive muzzle-moiety anteriorly is linked to the bulbous neural half posteriorly by a wasp-waisted speno-orbital region, which lends to the whole apparatus the structural instability of an hourglass. Consequently if a cudgel strikes a baboon's skull with any degree of momentum on either the muzzle, or the cranial box, or the exiguous isthmus that holds the two expanded extremities together, widespread shattering is inevitable. To this simple mechanical weakness must be attributed the almost total absence from these deposits of uninjured baboon skulls or mandibles (see illustrations, and especially figs. 1 to 12).

In this connection I should also state that at least three specimens from Taungs (5357 Ct., 5367 Ct., and 5374 Ct.), which had not been admitted in my original list of intentionally damaged specimens, were added thereto after the structural weaknesses of the human skull had been brought to my notice by Professor Mackintosh and had been illustrated by the outstanding series of lethally injured human skulls housed in his Museum of Forensic Medicine and prepared by his Senior Laboratory Assistant, Mr. A. E. Watkins, who was previously a member of the Department of Anatomy staff.

Out of the 58 baboon specimens 14 (4 from Taungs, 5 from Sterkfontein and 5 from Makapansgat) are jaw fragments (see figs. 13 to 24). Thus, although their fragmentation, as we shall see, is suggestive of bludgeon work, nearly 25% of the specimens have been set aside as too meager to afford by themselves a secure idea of the precise cause of their pre-fossilizational damage. Various other specimens (e.g., the calvarial fragment 947 A.D. from Taungs, the juvenile skull 1238/33 A.D. from Sterkfontein, the infantile skull with endocranial cast 1238 A.D. 35 A. & B. from Sterkfontein), like the maxillary and mandibular fragments were also damaged before fossilization but give no sure evidence about the causes of that damage. The facts noted are set out for each individual specimen in the accompanying tabulations but even when



these exceptions are made the evidence is overwhelming. It is not dependent on individual specimens but upon the picture of instrumental violence which the tabled descriptions and illustrative plates present as a whole.

If the diagnoses are correct, 27 out of 42 skulls from the three deposits (i.e., approximately 64% of the skulls) were fractured by blows delivered directly from the front. Seven skulls (i.e., approximately 17%), and presumably most of the skulls represented by jaw fragments, were fractured by strokes delivered on the left side and also presumably from the front. Only two skulls (or less than 5%) appear to have received blows delivered on the right side. The *Australopithecinae* seem therefore to have had a preference for the right hand. A small number of strokes, i.e., 6, appear to have been delivered in stealth from the rear and again with the right hand. Similarly with the 6 *australopithecine* specimens, 4 appear to have received more or less vertical shocks, while two died from blows in the left lateral region of the skull, the attack in most cases coming presumably from the front.

It appears therefore that in general, as far as attacks upon baboons and fellow *australopithecines* were concerned, the onslaught was direct or face to face, and highly accurate.

The vast majority of the injuries are depressed fractures of the skull (32 out of 42 or over 75%) or smashing fractures of the muzzle. All this work appears to have been performed by bludgeons of wood or bone or stone.

#### AGES OF THE SPECIMENS

Any creature would require courage to attack baboons systematically, for they defend one another and will fight for their young to the death. Boldness of attack is also shown by the adult age of the specimens. Out of the 21 baboons found at Taungs, one is an infant, 5 are juvenile and three are of unknown age; the majority, i.e., 12 are adults. The sex of two of these adults is indeterminable; but of the other 10, 6 are male and 4 are female. The indications of Sterkfontein are that there was a greater tendency to seize infants and to batter

savagely the heads of older specimens in several places, rather than to finish them with a single, shrewdly-placed blow as at Taungs.

At Makapansgat, out of 15 specimens two are infants, and two are juvenile; once again the majority (11) are adult; and of the 6 in which the sex is determinable, 4 are male and two are female. At Makapansgat the blows are powerful and the fractures extensive, like those seen in the Sterkfontein specimens. It is to Makapansgat too, as also to Taungs, (three each) that the specimens suggesting stealthy attack from the rear are attributed.

#### SPECIFIC NATURE OF DAMAGE

The plates have been made to illustrate various novel features that have emerged from this investigation, which may be briefly summarized.

*Double-depressional fractures and ungulate humeri* (plate 1). The frequency in incidence of depressed fractures (75%) accounts for their having formed the subject matter of previous references to the hunting ability of the Australopithecinae. But the unexpected and originally very puzzling phenomenon was the distinctive type of depressed fracture to which I have given the foregoing appellation, and whose characteristics are exhibited in the series of baboon skulls portraying this lesion (figs. 1-7). Of the 7 specimens illustrated, three came from Taungs, two from Sterkfontein, and two from Makapansgat. Consequently the same sort of weapon was used at all three sites. All of the blows were apparently delivered from the front except one (lower right hand corner) from Taungs, which was probably hit from the rear.

In some instances (e.g., figs. 5 and 6) more than one blow may have been struck, as the skulls have been so greatly distorted; but the duplex character of the final impressions left and the V-shaped outlines of the depressed areas in other skulls (cf., figs. 4 and 7) demonstrate clearly that a double-

headed implement with vertical edges between the two heads must have been employed to execute damage of this special character.

A blow with the same sort of implement was certainly responsible for the type of damage exhibited by the *Plesianthropus* endocranial casts from Sterkfontein (see fig. 26). The impact caused the right parietal bone to break along the line of the sagittal suture just behind the bregma, while the two depressions in the right parietal bone on either side of the fractured median ridge reflect the lateral outlines of the double-headed club that caused it. Meantime this accurately directed vertical blow shattered the frontal bone and forced the lower edges of the right parietal bone down under the overriding temporal squama. The blow was perhaps delivered from the rear, as its right side is the more deeply indented.

The V-shaped outline shown by the upstanding portion of the left parietal region of the other endocranial cast of *Plesianthropus* (fig. 25) indicates that this specimen may also have received a blow from a double-headed object (see also plate 3, B, in Broom and Schepers, '46). But the depressed fracture extends transversely in jagged fashion across the two parietal bones from the point of the elevated V. The specimen being fragmentary, the full extent of the injuries cannot be followed; it is sufficient for our purpose that it also displays localized violence.

The recurrence at Taungs, Sterkfontein and Makapansgat of so characteristic a type of cranial trauma caused me to have extracted from the Makapansgat grey breccia any object that might have been big enough to serve as a tool. Investigation of this sort still continues. No stone tools have been discovered hitherto but although a number of ungulate long bones were extracted from the limestone with their ends intact, it was rare to find an ungulate humerus whose epicondylar ridges had not suffered extensive damage prior to fossilization (see fig. 8). The damage done to the distal ends of the 6 ungulate humeri shown in this plate is pre-fossilization, as is

evident from the coating of lime, which has been left in position in some areas the better to display the broken condition in which they were found.

Most of these humeri also display longitudinal fractures of the shaft, such as may have been caused in the process of extracting the narrow, but the terminal damage to the double ridges of these bones is of deeper interest. The multiple fracturing of the ridges has left too jagged and irregular an outline for it to have been caused by gnawing, but the contour of the damaged ends of the humeri is consistent with the concept of their employment as bludgeons. Further, if the two epicondylar ridges on any of these humeri are placed in juxtaposition with the double depressions found in the baboon crania (or the australopithecine endocranial casts) from Taungs, Sterkfontein and Makapansgat, the correspondence between the humeral epicondylar contours on the one hand and the fractures on the other hand is too close to be attributed merely to the long arm of coincidence. The evidence indicates that the characteristic implement of *Australopithecus* was a mace or bludgeon of bone, preferably the humerus of an ungulate.

*Distorted muzzles and fractured mandibles* (figs. 9 to 24). The violence done to cranial roofs and walls by bludgeons, and the fragility of the baboon skull, prepares us for the frequent occurrence in these deposits of isolated jaw fragments exhibiting clean pre-fossilizational lines of fracture, and multiple fractures accompanying distortion. In some instances, despite the extensive injuries sustained by the skulls both before and after fossilization, the skulls and jaws have been retained in adequate contact and completeness for the story of distortion by smashing of the muzzle to be unmistakable. This has been set forth fully in the protocols. Plate 2 has been prepared to show three skulls from Taungs and one from Makapansgat illustrating twisting of the muzzle relative to the cranium, or of the jaws relative to one another.

In one of these skulls (no. 5356 Taungs) the distortion was caused by a blow from the rear with a double-headed bludgeon



(see fig. 7) which displaced the cranium relative to the muzzle (see fig. 10). In the other three the impact of the blow was received over the zygomatic arch or side of the face and has resulted in a total displacement of the muzzle relative to the cranial box (fig. 9); or shattering of the skull and displacement of the jaws relative to one another (fig. 11); or displacement of the lower jaw relative to the upper jaw (fig. 12).

These typical instances of twisted muzzles and shattered jaws show that many of the large series of maxillary and mandibular fragments, typical examples of which are exhibited in figures 13 to 24 — must have been produced in the same way. These specimens have not been claimed as evidential of manual violence, though it is patent that many of them could not reasonably be interpreted otherwise. In the first place they all show isolation from the remainder of the skull; and secondly they do not exhibit marks of gnawing teeth, but clean lines of fracture. In the third place the symphyseal fracture and compression of the two sides of the mandible together at the site of fracture (seen in figs. 17 and 18) and the comminution (fig. 18) are virtually diagnostic of violent shattering. In conjunction with the foregoing evidence these baboon jaws from Taungs, Sterkfontein and Makapansgat illustrate the general nature of australopithecine cavern deposits.

*Punctured depressions* (figs. 28 to 32). This group of cranial injuries is extremely interesting as it is suggestive of the employment of pointed objects causing penetrating wounds. Figure 31 (specimen 5356 from Taungs is once again illustrated, this time in lateral view) shows how the lower margin of the blow from the double-headed implement terminated anteriorly in a punctured depression lined by lime crystals.

Figure 32 (specimen 1238/11 from Sterkfontein) is rather similar in that it displays a puncture-like wound (filled with lime crystals) but surrounded by a ring-like area of depressed fractured bone. These two punctures probably owe their ex-

istence to knobbed or jagged excrescences on the bludgeon employed.

The other three specimens (figs. 28 to 30) are in a different category. The holes are small and triradiate or almost circular; and there is no general depression of the surrounding skull, such as would indicate a blow from a bludgeon. They look like thrusts, with a rounded or triangular-sectioned object, like a horn-tip or a pointed bone-shaft. Such horn-tips, broken off at the tip before fossilization, have also been found in the breccia.

Where man-like apes were intentionally killing wild beasts and smashing the shafts of their long bones with other long bones as hammers or pounders to extract the marrow, it would inevitably happen that the jagged ends of suitable broken long bones would also be used for tearing and thrusting, even if no deliberate attempt was made to shape them for this purpose. Our collection of long bones is not as yet sufficiently extensive to prove, or disprove the fashioning of bone tools; but it does indicate the employment of broken long bones as bludgeons and suggests the use of their worn down or broken ends for thrusting.

*Openings of skulls and crushing by hand* (plate 5). In many skulls the cranium is deficient above, behind or below; alternatively calvarial fragments are found isolated from the rest of the skull. These suggest, but do not prove, the deliberate opening of skulls to extract their cerebral contents. But specimens such as are exhibited here, both cranial and endocranial (see figs. 33 to 40), prove by the irregularly circular nature of the cranial deficiency, the deliberate performance of an intentional technique of brain removal. One of the specimens from Taungs (fig. 34) is of special interest, because it displays by the shearing off of the outer table of the calvaria — as Professor Mackintosh was the first to recognize — that after the bone had been elevated by means of finger and thumb, it had been torn away from within outwards.

Another specimen of particular importance is the juvenile skull from Sterkfontein (no. 1238/16, figs. 37 and 39, seen

from both vertical and lateral aspects), because it illustrates two facts: first, that the fragile roof of the shattered skull was broken and removed piecemeal; and second, that during the removal it was held between the fingers and thumb of the left hand. Two discrete impressions, that could have been caused apparently only by a shifting left thumb, are still plainly palpable and visible in the anterior and posterior portions respectively of the cracked left parietal bone.

To demonstrate that this finger work is far from being fortuitous in occurrence, two other juvenile specimens from Sterkfontein have been included (figs. 38 and 40) to show the generalized crushing they also suffered. Each fits so neatly into the left hand of a human being, that it is impossible to avoid the deduction that, either during the process of evacuating their contents or afterwards, they were crushed by a similar hand and subsequently discarded like empty eggshells. In this connection the occurrence of actual birds' eggshells and tortoiseshells at Taungs and of occasional bird bones at Makapansgat, should also be recalled.

Many higher primates extract nuts from their shells or fruits from their discarded coverings. These manipulations of skulls, which become rational only on the assumption of deliberate evacuation of their contents, are to be regarded as an extension of these habits allied to the penetrant or perforational technique illustrated in figures 28 to 32. Living anthropoids also have the intelligence to utilize levers when necessary! It is obvious from these cranial documents that once an entrance had been established in a skull, these australopithecines had the ability by the use of their fingers, perhaps aided by slivers of bone — of which there are many present — to widen those openings piecemeal and to extract from the more capacious interior of the cranium through even a relatively small orifice its desirable contents. Attention should also be drawn here to the thoroughness with which in repeated instances narrow cavities of long bones have been opened up (see fig. 8, second from left in bottom row) by splitting or

leverage or both, so as to expose their contents completely, and to produce incidentally reasonable weapons for cracking or piercing purposes.

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## PLATE 1

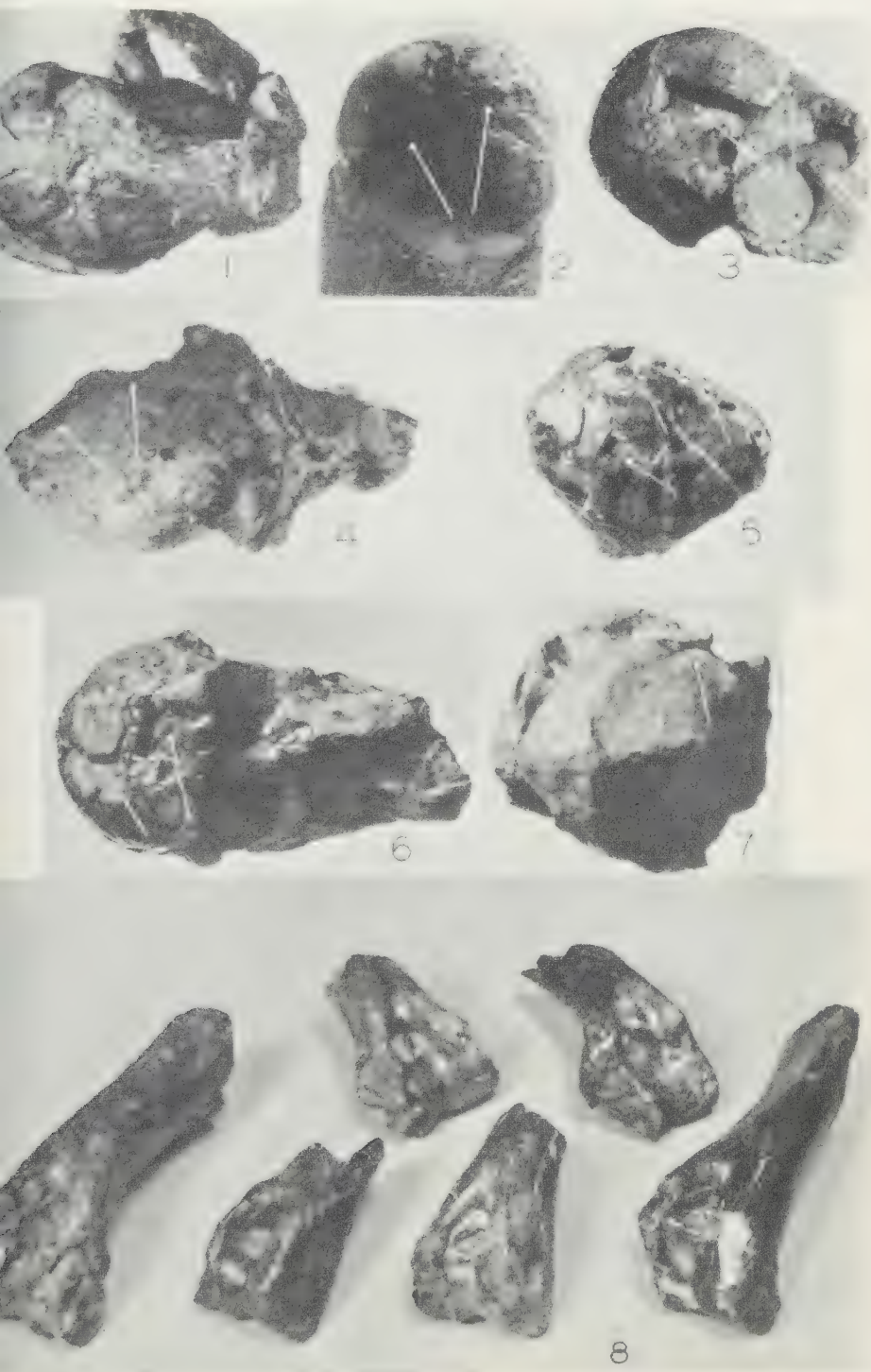
## EXPLANATION OF FIGURES

(All photographs except figure 27 by Mrs. G. Chaplin.)

Figs. 1-7 Double-depressional fractures.

- 1 No. 419 Tvl. (Sterkfontein). Adult calvaria of ? *Parapapio whitei*, and mandible of old adult, probably *Parapapio jonesi*.
- 2 No. 1326/14 A.D. (Makapansgat). Infantile calvaria of indeterminable species.
- 3 No. 5365 Ct. (Taungs). Juvenile skull, probably *Parapapio africanus*.
- 4 No. 621 Tvl. (Taungs). Adult female calvaria of *Parapapio africanus*.
- 5 No. 457 Tvl. (Sterkfontein). Adult calvaria of indeterminable species.
- 6 No. 1326/4 A.D. (Makapansgat). Adult skull, probably of *Papio darti*.
- 7 No. 5356 Ct. (Taungs). ? Male adult skull of *Parapapio africanus*.
- 8 Ungulate humeri. A series of ungulate humeri recovered from the *Australopithecus prometheus* horizon at Makapansgat Limeworks exhibiting longitudinal fractures of the shaft and fractured epicondylar ridges, which illustrate the violent usages to which they had been subjected or applied prior to fossilization.





## PLATE 2

### EXPLANATION OF FIGURES

Figs. 9-12 Distorted muzzles.

9 No. 5637 Ct. (Taungs). Endocranial cast and muzzle (maxillary portion absent), probably a female *Parapapio izodi*.

10 No. 5356 Ct. (Taungs). ♀ Male adult skull of *Parapapio africanus*.

11 No. 1326/3 A.D. (Makapansgat). Basal view of adult male skull of *Cerco-pithecoides williamsi*.

12 No. 946 A.D. (Taungs). Adult female skull, paratype of *Parapapio izodi*.



## PLATE 3

### EXPLANATION OF FIGURES

Figs. 13-24 Fragmented jaws.

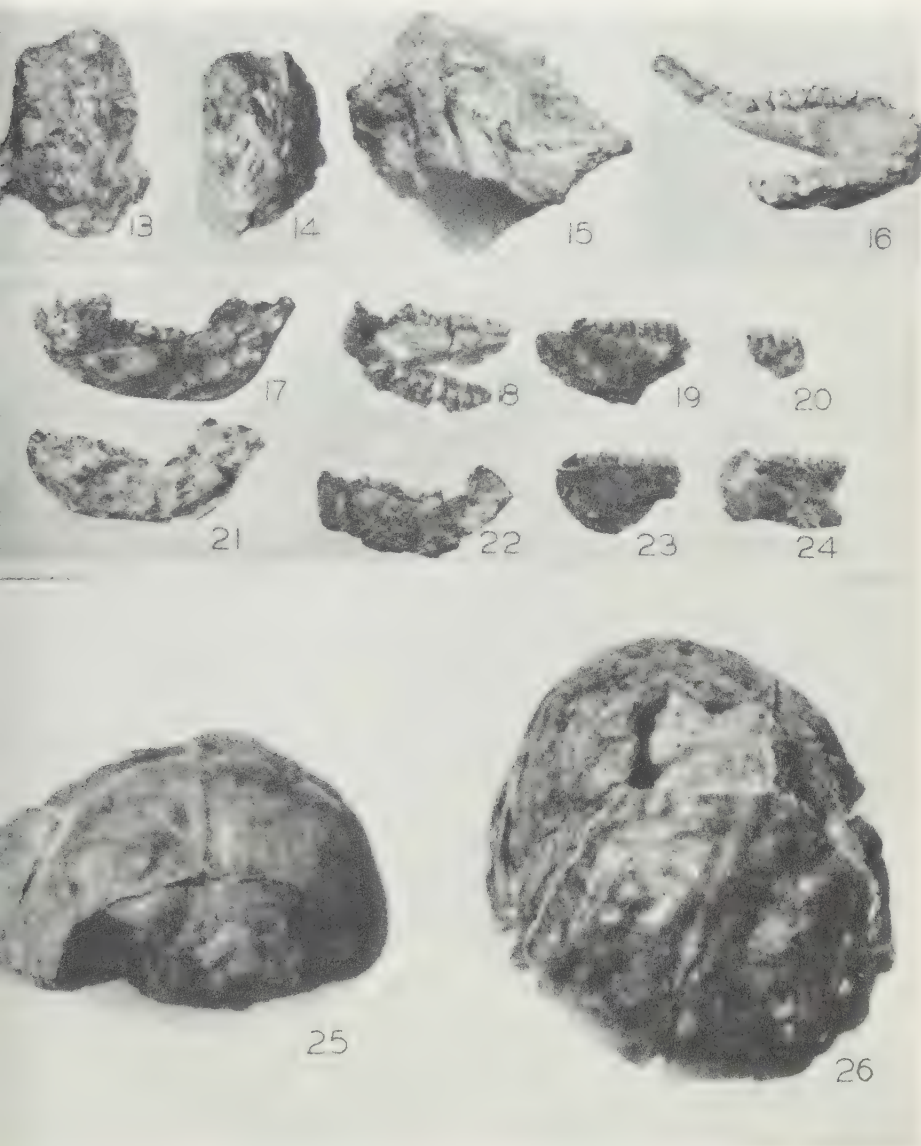
- 13 No. 1238/17 A.D. (Sterkfontein). Upper jaw, probably *Parapapio whitei*.
- 14 No. 5360 Ct. (Taungs). Upper jaw, male, probably *Parapapio africanus*.
- 15 No. 944 A.D. (Taungs). Lower jaw, sex indeterminable, *Parapapio africanus*.
- 16 No. 1326/1 A.D. (Sterkfontein). Adult male mandible, *Papio darti*.
- 17 No. 1460 Tvl. (Sterkfontein). Adult female mandible type *Parapapio whitei* Broom.
- 18 No. 1238/13 A.D. (Sterkfontein). Adult female mandible, paratype *Parapapio broomi* Jones.
- 19 No. 1326/13 A.D. (Makapansgat). Adult male mandible, referred to *Parapapio broomi*.
- 20 No. 1326/11 A.D. (Makapansgat). Adult mandible, sex indeterminable, referred to *Parapapio broomi*.
- 21 No. 501 Tvl. (Sterkfontein). Adult female mandible referred by Broom to *Parapapio broomi*.
- 22 No. 1238/37 A.D. (Sterkfontein). Adult male mandible referred to *Parapapio jonesi*.
- 23 No. 1326/12 A.D. (Makapansgat). Adult female mandible referred to *Parapapio broomi*.
- 24 No. 22M B.P.I. (Makapansgat). Adult mandible, sex indeterminable, referred to *Parapapio broomi*.

Figs. 25-26 Depressed fractures displayed by endocranial casts of *Plesianthropus*.

25 *Plesianthropus transvaalensis* Broom, endocranial cast of type 3. Fracture appears to have been produced by a more or less flat bludgeon.

26 *Plesianthropus transvaalensis* Broom, type 2. Fracture appears to have been produced by an implement with a double-ridged extremity.





## PLATE 4

### EXPLANATION OF FIGURES

27 *Paranthropus robustus* Broom. Photograph of the endocranial aspect of the left temporal bone of *Paranthropus*, taken by Dr. G. W. H. Schepers during the process of developing the skull, showing the marks of the dental burr around the stone which he found, embedded in the breccia and separated from the temporal bone by fragments of the parietal bone which it had probably crushed.

Figs. 28-32 Punctured depressions.

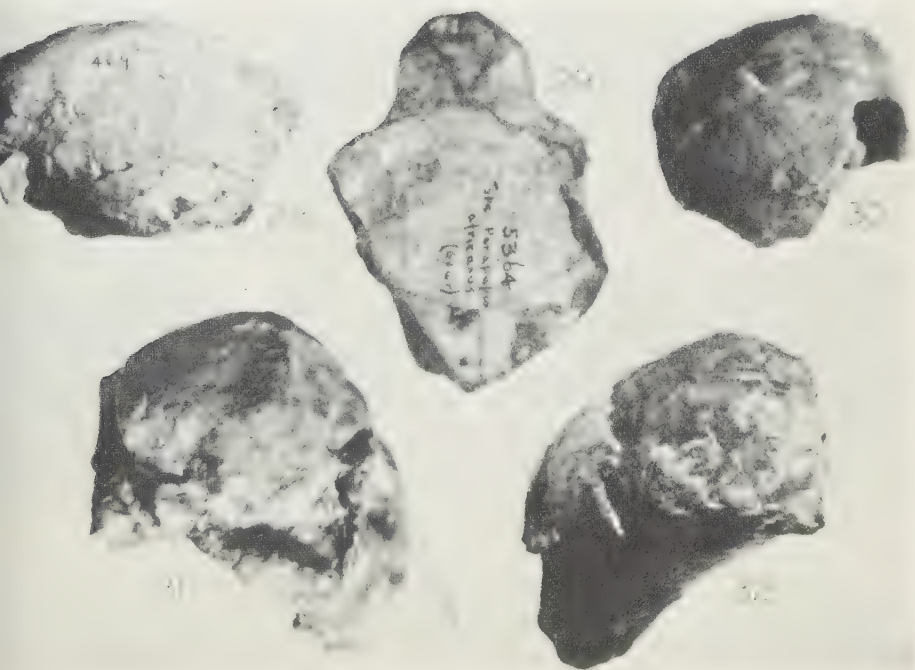
28 No. 469 Tvl. (Sterkfontein). Adult skull of indeterminable sex, referred to *Parapapio broomi*.

29 No. 5364 Ct. (Taungs). Adult male skull, type *Parapapio africanus* Gear.

30 No. 5358 Ct. (Taungs). Adult skull of indeterminable sex, probably *Parapapio africanus*.

31 No. 5356 Ct. (Taungs). Adult skull, probably male, of *Parapapio africanus*.

32 No. 1238/11 A.D. (Sterkfontein). Adult skull, type *Parapapio broomi* Jones.



## PLATE 5

### EXPLANATION OF FIGURES

Figs. 33-37 Opened skull roofs.

33 No. 1238/10 A.D. (Sterkfontein). Calvaria of indeterminable sex and age, probably *Parapapio broomi*.

34 No. 992 A.D. (Taungs). Skull, probably adult female, type *Parapapio izodi*. Gear.

35 No. 5366 Ct. (Taungs). Calvaria, probably *Parapapio izodi*.

36 No. 945 A.D. (Taungs). Endocranial cast, probably *Parapapio izodi*.

37 No. 1238/16 A.D. (Sterkfontein). Infant skull, probably *Parapapio broomi*.

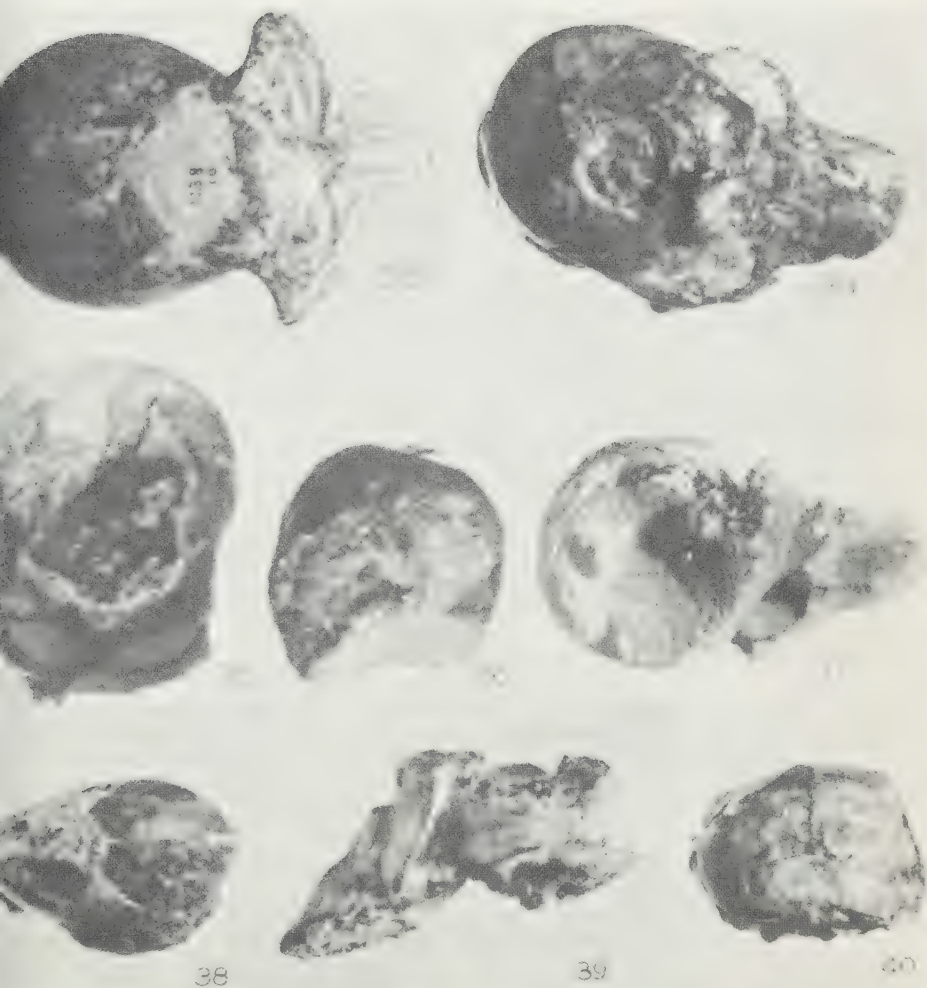
Figs. 38-40 Crushing with hand.

38 Unnumbered specimen, Tvl. (Sterkfontein). Infant skull of indeterminable species.

39 No. 1238/16 A.D. (Sterkfontein). Infant skull, probably *Parapapio broomi*.

40 No. 585 Tvl. (Sterkfontein). Infant skull of indeterminable species.





## APPENDIX

This is a tabulated inventory of all the pertinent fossil material. In each case, following the general description of each specimen, paragraph *A* records the nature of damage suffered by the specimen prior to fossilization, and paragraph *B* gives the estimated cause of this damage.

*Fossil baboons from Taungs*

1. 5356 Ct. Calvaria and muzzle of adult, ? male skull including the three left and posterior two right maxillary molars: mandible absent. Anterior portion of upper jaw, a superficial flake from the nasal bones and anterior part of the two frontal bones removed during blasting; thus exposing endocranial cast and cast of upper half of right orbit. *Parapapio africanus*, Gear. See figures 7, 11, 31.

*A.* Muzzle twisted to the left at angle of 15 degrees relative to mid-sagittal plane. Sagittal and coronal sutures, right and left temporo-parietal sutures and pterionic regions have been sprung apart. Left zygomatic arch broken away and left temporal bone fractured, so allowing the twisting of the muzzle to the left. Occipital bone and whole of skull base posterior to the pterygoid laminae and basisphenoid absent. The frontal arch forms an abrupt angle of 138 degrees with the parietal arch at the bregma, where the sutural springing is maximal. The bregmatic angle of the right parietal bone is depressed 2 mm below the level of the bregmatic angles of the adjacent frontal and parietal bones; the asterionic angle of the same bone is depressed 5 mm below the mastoid portion of the right temporal bone.

*B.* A powerful downward, forward and inward blow delivered from the rear upon the right parietal bone by a double-headed object (e.g., epi-condylar ridges of ungulate humerus) and evacuation of skull contents.

2. 5357 Ct. Endocranial cast virtually complete and lying in symmetrical relationship to a tolerably complete adult mandible with posterior two left molars and overlying cast of the inferior surface of the maxilla: sex indeterminable. *Parapapio izodi*, Gear.

*A.* The right and median fronto-orbital regions of the endocranial cast are missing as a result of recent (during blasting) fracture; but the right lateral (Sylvian) half of the missing part is lime-encrusted and elevated at its margin in such a way as to show that the bone was missing from that region prior to fossilization. Localized distortion of the cast surrounding this region indicates that the skull suffered a depressed fracture of the frontal bone which extended into the right orbit.

*B.* A light downward, backward and inward blow delivered from the front upon the right frontal bone.

3. 5358 Ct. Posterior two-thirds of calvaria of an ? adult skull (of indeterminable sex) central portion of which has been blasted off exposing the endocranial cast. Species undetermined. Probably *Parapapio africanus*, Gear. See figure 30.

*A.* The infero-lateral portion of the left parietal bone displays an equilateral 5 mm triradiate area where the skull has been *punctured* and filled with lime crystals; the portion of bone below this is slightly depressed; 8 mm posteriorly to the triradiate puncture the left parietal, occipital and temporal bones are missing over an area (30 × 40 mm approximately) where the endocranial cast is deficient and its lime-encrusted margin is sufficiently elevated to demonstrate that the bone was fractured there before fossilization. The right parieto-temporal suture is slightly sprung and the right parietal bone exhibits a fracture running antero-posteriorly.

*B.* A lateral, forward and inward blow delivered from the front upon the left parieto-occipital bones, probably with a double-headed object.

4. 5360 Ct. Anterior portion of left adult male maxilla containing a fully erupted and well worn canine tooth along with the two premolars. Probably *Parapapio africanus*, Gear. See figure 14.

A. The recently fractured (during blasting) bone surface is continuous around the periphery of the whole specimen. There is nothing in the fragment to indicate pre-fossilization damage.

B. No evidence.

5. 5364 Ct. Maxillary portion of muzzle, orbital region and anterior half of calvaria of a young adult male: teeth broken off at alveolar margin. Type *Parapapio africanus*, Gear: allocation by Trevor Jones, '36. See figure 29.

A. A circular (6 mm diameter) *puncture* filled with lime crystals in the bregmatic angle of the left parietal bone. Skull base deficient posterior to pterygoid laminae of sphenoid bone.

B. Direct downward blow delivered from the front with a pointed object in bregmatic region. Evacuation of skull contents.

6. 5365 Ct. Skull and posterior (circumorbital) region of a juvenile (calvaria 3 mm thickness) face of indeterminable sex: no teeth present. Probably *Parapapio africanus*, Gear. See figure 3.

A. A depressed (8 mm depth) fracture ( $30 \times 27$  mm) of right frontal bone severing frontal bone along the mid-line into the right orbit and along the right fronto-parietal suture, shattering the medial halves of the orbital roofs and partially crushing down the left orbit and muzzle. The frontal bone is distorted and cracked on both sides but especially on the right side where the fractured portion is hinged along its parietal and sphenoidal sutural margin. This hinged region and the V-shaped island of bone left standing above the obvious depression of the cranium shows that the implement used to smash it was double-headed. The parietal bones also exhibit splits radiating from the site of the principal fracture. Remainder of brain case intact: no evidence of opening the skull.

B. A direct downward blow upon the right frontal bone and muzzle delivered from the front with a V-shaped double-headed object having vertical internal borders or sharp margins (e.g., ungulate humerus) and measuring approximately 30 mm between the two heads (e.g., epicondylar ridges).

7. 5366 Ct. Calvaria and posterior (circumorbital) region of an infantile (calvarial bone 1.5-2 mm thickness) face of indeterminable sex: milk dentition fully erupted, first permanent molar on point of emergence. Probably *Parapapio izodi*, Gear. See figure 35.

A. An irregular pear-shaped opening ( $46 \times 34$  mm) stretching diagonally across the two halves of the frontal bone and the anterior part of the left parietal bone. The margin of the opening is formed by lime-encrusted bone or by a slight eminence (where surrounding bone has been blasted away). There is a further depression ( $15 \times 10$  mm) distorting the middle part of the anterior border of the right parietal bone. The right pterionic suture has been sprung and the surrounding bones are comminuted. The skull base is absent posterior to the pterygoid laminae and the calvarial margin presents a jagged outline.

B. A direct downward blow delivered from the front on the front half of the skull with a double-headed object leading to shattering of skull and evacuation of its contents.

8. 5367 Ct. Adult endocranial cast and muzzle, probably female very similar in general appearance to serial number 2 (specimen 5357) above; the endocranial cast virtually complete, with its posterior and basal surfaces still encased in the skull. The shattered mandible has been separated about 10 inches from the maxilla, portion thereof being visible in the breccia at a couple of inches distance. The maxilla has been twisted to the right, so that its mid-line is at an angle of 10 degrees to the sagittal plane of the skull and cast, and shaped so that the alveolar plane slopes upwards to the right. Probably *Parapapio izodi*, Gear. See figure 9.

A. The damage suffered was necessarily outlined in part in the general description. In addition a line of breccia-filled fracture runs diagonally across the left orbit and the right speno-maxillary region. The endocranial cast is deficient over both orbital margins and the left temporo-sphenoidal lobe; but it is only over the lime-encrusted left side that the bone was obviously deficient. Above and continues with this deficient area there is an irregularly depressed area ( $10 \times 20$  mm) of the cast. Posteriorly on the same (left) side of the skull the temporo-occipital suture is slightly sprung.

B. A smashing downward and inward blow delivered from the front with a bludgeon on the lateral part of the left frontal bone, zygomatic arch, and muzzle.

9. 5374 Ct. Endocranial cast of apparently juvenile skull; sex indeterminable; from general form and appearance of the cast is probably *Parapapio africanus*, Gear.

A. Cast virtually perfect except for a deficiency ( $30 \times 15$  mm) over the right frontal margin and the region of the right Sylvian fossa. There are slightly depressed and roughened areas to the left and right of the sagittal sinus in the frontal region probably linked with the deficiency of the right frontal lobe. A roughened depression ( $15 \times 10$  mm) lies in the area under the postero-medial angle of the left parietal bone and a smaller depression ( $5 \times 5$  mm) somewhat further outwards in the area under the postero-medial angle of the right parietal bone. There is slight distortion of the right occipital region, and the irregularity of the cast along the parieto-occipital suture shows that it was sprung.

B. A direct downward blow delivered from the rear on the back of the head and a second on the lateral part of the right frontal.

10. 2830 Ct. also known as Tl. and 941 A.D. Endocranial cast complete save for deficiencies at (a) frontal part of the right temporo-sphenoidal lobe, (b) the base and left parieto-temporo-occipital region, (c) an oval puncture-like depression ( $5 \times 7$  mm) slightly in front of the center of the area covered by the right parietal bone. Probably from an adult male skull of *Parapapio africanus*, Gear.

A. Deficiencies at tip of right temporo-sphenoidal lobe and in right parietal region may be due to skull damage; but the most extensive damage was that involving the postero-inferior part of the left parietal bone and causing the removal of the mastoid portion of the left temporal bone and the whole of the occipital bone. The lambdoid, sagittal and coronal sutures were sprung, the left temporal bone smashed and the skull base removed posterior to the pterygoid laminae.

B. An inward and forward, lateral blow delivered from the front with a broad object on the left side in the parieto-temporo-occipital region and evacuation of the skull contents.

11. 943 A.D. also known as A. Muzzle of adult male including body of mandible, the mandibular dentition (except the incisors, two posterior left molars and right canine) and the right maxillary molars and premolar dentition. The palate is represented by a cast of its inferior aspect. The pterygoid and choanal region is preserved posterior thereto. *Parapapio africanus*, Gear.

A. No evidence.

B. No evidence.

12. 944 A.D. also known as T. 4. Posterior half of left body and ascending ramus of mandible, first and second molars present and third molar partially erupted. Sex indeterminable. *Parapapio africanus*, Gear. See figure 15.

A. Separation from skull.

B. No evidence.

13. 945 A.D. also known as T. 5. Endocranial cast from which the frontal lobes have been blasted away. The material of the cast looks like lime-consolidated ash and varies from yellow to ash-grey and black in color. Probably *Parapapio izodi*, Gear. See figure 36.



A. The skull had been so much damaged (? by fire) that only the left fronto-parietal and right occipital halves of the cast and its median region have given a faithful replica of the internal skull contours. A depressed fracture crosses the left parietal area running up to the bregma from the left temporo-parietal suture. The right fronto-parietal region is in part irregularly outlined by very friable and eroded bone, which is encrusted with black (? carbon) stained lime like the amorphous tract thus partially surrounded. This dusky amorphous lime-encrusted area extends across the pre-occipital part of the skull base to become confluent with a similar area extending over the left lower half of the temporal, parietal and occipital regions of the cast.

B. A downward blow delivered from the front over the right frontal bone followed by evacuation of contents, partial incineration of skull and filling with ash.

14. 946 A.D. also known as T. 6. Anterior part of right side of skull, orbit and almost complete upper jaw of adult female, maxillary dentition complete on left side. Considerable part of fractured mandible attached. Paratype of *Parapapio izodi*, Gear, figured by Broom, '34 as *Papio africanus*, Gear; and '40, '46 as *Parapapio africanus*, Gear. See figure 12.

A. From the jagged outline of skull and bony fragments lying in relation thereto it is clear that the skull was smashed, the zygomatic arches broken and the mandible fractured at the symphysis, its two halves being approximated and their lower borders twisted to the right.

B. A violent blow delivered from the front over the left temporal region.

15. 947 A.D. Calvarial fragment ( $50 \times 40$  mm) with jagged edges, apparently a piece of parietal bone. Species unknown.

A. Removal from skull and warping.

B. No evidence.

16. 992 A.D. also known as T. 2. Skull, probably an adult female, virtually complete save for anterior extremity of maxilla; mandible absent. Where bone has been blasted away in left inferior part of the lateral and posterior aspects of the skull a natural excellent endocranial cast is visible. Type *Parapapio izodi*, Gear; allocation by Trevor Jones, '36. See figure 34.

A. Removal of mandible; fracture of left and right orbits, right zygoma and both maxillae. A roughly circular opening ( $30 \times 30$  mm) occupies the central part of right frontal bone region, and the interparietal portion of the sagittal suture is sprung so that the right parietal bone is elevated (1 mm) above the left. Most of the margin of the circular opening is lime-encrusted like its center but the medial margin is relatively clear and displays shelving outwards such as could have been produced only by deliberately elevating the broken bone.

B. A downward blow delivered from the front on the right orbit and frontal bone with a broad object, and deliberate opening of the skull by elevation of the broken bone in search of its contents.

17. 993 A.D. also known as T. 3. Neural portion of adolescent (? female) cranium. Area ( $30 \times 35$  mm) around lambda removed by blasting exposing the sprung sagittal and interparietal sutures, cerebellar eminences of the endocranial cast and the calvarial (2-3 mm) thickness. The left orbital margin, east of left orbit and the part of the skull covering the east of the left temporo-sphenoidal lobe-region were removed with the muzzle in blasting. Probably *Parapapio izodi*, Gear.

A. In addition to the springing of the sutures, there is a gaping (2-8 mm wide) depressed fracture running transversely across both parietal bones to the regions (approximately a centimeter from their sutures with the temporal bones) where they communicate on each side with radially (chiefly antero-posteriorly) running intraparietal fractures. The posterior halves of the parietal bones stand 2 mm above the front halves. The right and left orbital margins were broken away and

radiating fractures run posteriorly from that region through the right half of the frontal bone; and the right zygomatic arch was broken.

B. Vertical blow delivered from the right side on the right parietal bone region of the skull possibly with a double-headed object. A second blow over orbital margins and muzzle.

18. 577 Tvl. Virtually entire mandible of an adult male containing second premolar and three molars (all well worn) on left side and first and second premolars on the right side. *Parapapio africanus*, Gear.

A. Separation from skull. Half a dassie mandible lies exposed in the limestone between the two ascending rami of the baboon mandible.

B. No evidence.

19. 588 Tvl. Virtually entire brain case and posterior portion of face of an infantile skull of indeterminable sex, with first two permanent upper left molars erupted and second premolar on left side just erupting. On right side second molar alone present. Where skull has been blasted away in left parieto-occipital region an excellent endocranial cast is present. The skull and cast were separated into two fragments in blasting: these have been reassembled. *Parapapio izodi*, Gear.

A. An irregularly outlined opening into top of skull occupies most of the central parietal and postero-medial portion of the left half of the frontal bone (unfortunately the skull fractured here during blasting). The right zygomatic arch was broken and the anterior part of the right temporal bone broken away leaving a jagged margin. The right supra-orbital crest has been smashed away and fracture lines run from it postero-laterally to the infratemporal fossa and postero-medially across the left half of the frontal bone. The muzzle (maxilla) is also deficient over a diagonal tract (12-15 mm wide) leading from the left orbit to the mid-line and parallel to the main fracture line running from right orbit across left half of frontal bone.

B. A direct downward blow delivered on the right supraorbital crest and left side of muzzle with a (?) double-headed object.

20. 621 Tvl. Frontal and central parietal portion of calvaria together with circumorbital and circumnasal portion of the face of an adult female. The fragment has been blasted off the breccia and was also shattered into the two pieces now apposed to form a unit. *Parapapio africanus*, Gear. See figure 4.

A. The lateral wall of the left orbit deficient in inferior third. Most of the available margin of the left parietal bone has been smashed and bent downwards. This bending over a broad (22 mm) stretch, and the deficiency in the parietal bone posteriorly, and the left frontal bone anteriorly, as well as the radiating fractures through the parietal fragments show that the injury was caused by a double-headed object.

B. A smashing lateral and downward blow delivered from the left side with a double-headed object over the left parieto-temporal region.

21. 639 Tvl. A virtually complete endocranial cast (with portions of the skull adherent to it, remainder having been removed by blasting) and face almost complete to the anterior end of the nasal opening. Mandible absent but base of skull was apparently complete. *Parapapio africanus*, Gear.

A. There is an approximately equilateral triangular area (15 × 15 × 15 mm) the site of a depressed fracture (4 mm deep) and occupied by a bone fragment extending from the mid-line leftwards over the left parietal region just posterior to the coronal sutures. Coextensive with this area (both on the left and on the right side) are oval areas approximately 40 mm long and 25-30 mm broad where the surface of the cast is imperfect due to lime crystal encrustation and where the bone was partially, if not totally, removed before fossilization, especially in the right parietal bone area.

B. A direct downward blow delivered from the rear over the vertex (anterior parietal) of the skull with a blunt object (? stone) with a sharp-sided triangular end.

*Fossil baboons from Sterkfontein*

1. 1238/1 A.D. Left parieto-occipito-cerebellar quarter of a semi-endocranial cast. Front portion of the half cast has been blasted away. Species indeterminable.

A. Right face of the endocranial fragment is encrusted with lime crystals in a manner reminiscent of that exhibited by the endocranial cast of *Australopithecus africanus*. The cast margin is irregular and the portion that underlay the right portion of the frontal bone is depressed about a millimeter below the parietal bone at the coronal suture, so there is little doubt that the right side of the skull was shattered by an impact received principally over the right orbito-frontal region.

B. A downward blow delivered from the front on the right frontal and (?) parietal bones. Evacuation of skull contents (?).

2. 1238/2. A.D. Virtually complete endocranial cast of a juvenile skull (bone 2-5 mm thick) with upper halves of the two orbits and their casts *in situ* below the cast of the frontal bone. The cast presents no gross distortion but, as a result of defective filling or excessive leaching of its contents before solidification, has a widespread worm-eaten or honey-combed appearance. Diameter through parietal region 65 mm. ? juvenile specimen of *Parapapio broomi*, Jones.

A. Facial portion of skull broken away through orbits, left orbit and temporal bone region deficient, and whole of skull base removed leaving irregular lateral margin. Despite the honey-combed appearance it is clear from the surrounding elevation that the skull was pierced by a puncture (5 × 5 mm diameter) in the coronal suture a centimeter to the right of the bregma; the left frontal bone also suffered a fracture.

B. A downward blow delivered from the front and received chiefly by left side of skull in fronto-temporal region, and evacuation of skull contents. Piercing of right coronal suture.

3. 1238/9. A.D. Calvarial fragment of frontal bone (right and central portion) and endocranial cast of right fronto-parieto-occipital region of an adult of indeterminable sex. *Parapapio whitei*, Broom.

A. By its jagged and fractured margin this fragment is clearly derived from a skull that was smashed in the frontal region on the left side. An irregular piece of blue and white dolomite (50 × 40 × 10 mm) lies in the breccia underneath the skull in this situation.

B. One or more blows delivered from the front in the left fronto-temporal region and evisceration of skull.

4. 1238/10 A.D. Calvaria of indeterminate sex and age reconstructed from comminuted adult skull fragments lying in apposition in the breccia. Probably *Parapapio broomi*, Jones. See figure 33.

A. The central part of the frontal region is lined with limestone and must therefore have been removed over an area (40 × 40 mm approx.) face and base of occipital region absent but whether due to blasting is now indeterminable.

B. A direct downward blow delivered from the front on center of frontal bone region.

5. 1238/11 A.D. Adult skull (bone 4 mm thick) presenting excellent endocranial cast where bones (principally parietals and right temporal) have been blasted away. Anterior half of muzzle and teeth absent. Type specimen of *Parapapio broomi*, Jones, '36. See figure 32.

A. Depressed fracture over an area (35 × 25 mm diameter) in the left lateral parietal region containing a circular central depression (10 mm diameter) or puncture where the bone is absent and the space is filled with lime crystals. Another



fracture runs transversely across the area covered by the parietal bone approximately a centimeter behind the posterior margin of the large depressed area. The lateral wall of the left orbit, the left zygomatic arch and the left temporal bone were broken away and the cast and skull are deficient on the left side below a line that joins the mid-point of the left orbital roof with the left acoustic meatus.

B. A downward and inward blow delivered from the rear or left side with a jagged and penetrating object over the postero-lateral portion of the area covered by the left parietal bone.

6. 1238/13 A.D. Body of mandible of adult female with almost complete dentition. Paratype of *Parapapio broomi*, Jones, '36. See figure 18.

A. Fractured through symphysis and two halves crushed together.

B. Jaw crushed by a bludgeon or stone by blow on left side.

7. 1238/16 A.D. Skull of an infant at the stage of eruption of first permanent molar. Complete base and muzzle preserved but all teeth except first molar and left canine tooth broken off or absent. Bone 2.0 mm thick probably *Parapapio broomi*, Jones. See figures 37 and 39.

A. Extensive damage to and removal of cranial roof over an area ( $80 \times 60$  mm approx.) extending from nasal bones and orbits anteriorly to central parietal region posteriorly and to both infra-temporal fossae laterally. The lateral part of the left parietal and frontal bones have been crushed downwards and inwards at the parieto-temporal and pterionic sutures. When the base of the skull is placed in the fingers of one's left hand, the left thumb fits neatly into the two depressions on the roof margin where the bone was crushed and split. These depressions are thus apparently due to compression of the skull between the fingers and thumb of the left hand while it was manipulated. Its contents were probably removed from the opening in the antero-lateral portion of the roof.

B. Direct downward blow delivered from the front over the right fronto-parietal region and removal of most of calvaria for evisceration of skull. The roof was indented and crushed between the fingers and thumb of a left hand.

8. 1238/17 A.D. Right orbit and palate of an adult of a very robust- and short-, but high- and broad-faced type. Cf., *Parapapio whitei*, Broom. See figure 13.

A. Left half of palate comminuted and separated from right half in mid-line.

B. Downward blows delivered from front and left side upon left side of frontal and facial regions.

9. 1238/30 A.D. Calvarial fragment of adult comprising glabella and central portion of frontal bone, central parts of the two parietal bones, and upper part of occipital bone; also endocranial cast of frontal and parietal bones on the left side, medial half of left orbit and part of left maxilla and mandible. Cf., *Parapapio whitei*, Broom.

A. The whole outline of the fragment is comminuted and jagged; but in addition the frontal bone was split longitudinally and transversely; the coronal suture was sprung and two transverse fractures cross the parietal fragments. The margin of the area occupied by the endocranial cast shows a deficiency of  $29 \times 20$  mm in extent.

B. Skull and face smashed by one or several powerful blows delivered from front or right side on the right side, and evisceration of skull.

10. 1238/33 A.D. Posterior half of juvenile skull (1.5-2 mm thick). Base virtually complete as far forward as sphenoid bone on the right side, and roof as far as posterior part of frontal bone on left side. Left temporal bone and neighboring portions of skull absent. ? *Parapapio broomi*, Jones.

A. No distortion, and apart from slight springing of the right temporo-parietal suture there is nothing in available parts of the specimen to indicate violence. This is the type of specimen which, by its symmetry, enhances the evidence given by other specimens that their distortion was deliberate.

B. No evidence.



11. 1238/34 A.D. Upper part of facial and anterior portion of neural region of an infantile skull with complete milk dentition. ? *Parapapio whitei*, Broom.

A. The left fronto-zygomatic suture was sprung and the lime encrustation over the surface of the frontal bone over, and to the right of the mid-line shows that it was broken before fossilization.

B. Uncertain; but probable that it was opened before fossilization.

12. 1238 A.D. 35 A & B. Portion A is the right side of the neural part of an infantile skull and endocranial cast. Portion B is the facial portion of the right side of the skull with which it articulates and which is still embedded in the breccia. Species indeterminable.

A. The skull and the endocranial cast are defective in both the occipital and frontal regions in the center and on the left side; but there is no clear evidence that these deficiencies occurred before fossilization. A dolomitic flake ( $65 \times 20 \times 10$  mm approx.) lies in breccia about two inches away from the skull.

B. Uncertain, but probable that it was opened before fossilization.

13. 1238/36 A.D. Endocranial cast complete in posterior three-quarters but deficient in frontal and anterior part of the temporo-sphenoidal lobes.

A. Unfortunately interference with grinding tools has modified much of the original anterior face of the cast; but its superior margin has largely escaped, and its irregularity and elevation show that the anterior part of the frontal bone was removed before fossilization. Further its indentations on the right side show that this region probably suffered most in the fracturing that led to its removal.

B. Downward blow delivered from the front upon the frontal region affecting especially the right side.

14. 1238/37 A.D. Right half of adult male mandible, almost complete, referred to *Parapapio Jonesi*, Broom. See figure 22.

A. Fractured in symphyseal region and deficient in posterior and superior part of ascending ramus.

B. No evidence.

15. 419 Tvl. Calvaria of adult skull exposing endocranial cast where, owing to blasting, the bone happens to be deficient. ? *Parapapio whitei*, Brown. Attached below in the breccia is the crushed and very worn mandible of a small primate. ? *Parapapio jonesi*, Broom. See figure 1.

A. The sagittal line of the frontal bone veers to the right of the rest of the sagittal suture at the bregma at an angle of 10 degrees. The left frontal and anterior portion of the left parietal bones have been bashed inwards so that the surface they form lies 5 mm below that of the posterior part of the left parietal at the point of fracture, which runs across both parietal bones. The facial portion of the skull is absent and the calvaria everywhere ends in jagged fashion.

B. A lateral, inward and downward blow delivered from front or at side on the left parietal region and mid-line of the skull by a double-headed object. Evisceration of skull.

16. 457 Tvl. Calvaria and posterior facial portions of grossly distorted adult skull exhibiting an endocranial cast where, owing to blasting, the bone happens to be deficient. Species indeterminable. See figure 5.

A. One irregular depressed line of fracture extends transversely across the parietal region of the calvaria from one temporal bone to the other while another extends antero-posteriorly from the right orbit to the left parieto-occipital extremity of the specimen. Where these two major fracture lines meet there is a lime-filled depression ( $7 \times 15$  mm) along the line where the top fragment was squashed down. A second right-angled depression occurs on the transverse fracture line 15 mm to the right of the principal lime-filled depression. Several other minor fracture lines are visible on the distorted endocranial cast. The outlines of all the bones present are jagged and irregular.

B. A single blow with a double-headed object, or two major blows delivered from the front downwards directly upon the mid-line and to the right in the region covered by the parietal bones, causing squashing or flattening of the skull.

17. 469 Tvl. Calvaria of an adult skull of indeterminable sex presenting endocranial cast where, owing to blasting, the bone happens to be deficient. ? *Parapapio broomi*, Jones. See figure 28.

A. There is an approximately equilateral (6 mm) triangular puncture, lined by lime crystals in the left temporal bone (which has also been cracked) just above the posterior root of the zygomatic process, the left lateral part of the frontal bone is broken and lime-encrusted. The inferior portion of the skull below this region and the facial portion of the skull were apparently broken away. Right temporo-parietal suture is sprung.

B. A lateral blow delivered from front or left side on the left side of the skull in the frontal and temporal regions.

18. 501 Tvl. Right half almost complete adult female mandible, referred by Broom to *Parapapio broomi*, Jones, '46. See figure 21.

A. Separated from skull and fractured in front of canine tooth.

B. No evidence.

19. 585 Tvl. Posterior half of an infantile skull (1 mm thick) filled with breccia: Species indeterminable. See figure 40.

A. Depressed (4 mm) radiating fracture in left lateral parietal region which caused depression and buckling of skull along line of fracture running transversely through the middle of the parietal bones. The main fracture gives impression of being due to, or exaggerated by, crushing by left thumb, while cranium was being evacuated of its contents through anterior deficiency. The rock filling at the anterior margin of the skull shows that this part of the skull had been broken away before fossilization.

B. Destruction of anterior part of skull with a blow from front and crushing of posterior portion on left side between fingers and thumb during evisceration of cranial contents.

20. 1460 Tvl. Complete right side and anterior portion of left side of adult female mandible. Type *Parapapio whitei*, Broom, '46. See figure 17.

A. Separated from skull and fractured in symphyseal region and crushed.

B. Jaw crushed by bludgeon or stone, with blow from left side.

21. Unnumbered Tvl. Neural portion of infantile cranium (0.5–1.0 mm thick). Species indeterminable. See figure 38.

A. Skull grossly distorted by crushing along the line of the sagittal suture. Absence of occipital bone and posterior part of left parietal suggests that it was first struck in this region.

B. The specimen fits so naturally into left hand as to suggest that the crushing was done by a left hand.

22. 1238/38 A.D. Almost complete skull. Cf., *Papio spelaeus*, Broom. Atlas vertebra lying medial to right zygomatic arch.

A. Separation of mandible and rounded cavity in left temporo-parietal region.

B. Blow delivered from left side in temporo-parietal region.

#### *Fossil baboons from Makapansgat Valley limeworks*

1. 1326/1 A.D. Adult male mandible with virtually complete dentition. Type specimen of *Papio darti*, Broom and Jenkins. See figure 16.

A. Separation from skull and fractures of left ascending ramus and middle of right horizontal ramus or body.

B. No evidence.

2. 1326/2 A.D. Calvaria and upper face of an adult male skull, almost complete: second premolars and three molars present on both sides of palate. Referred by Mollett, '46 to *Parapapio broomi*, Jones.

A. Deficiency of occipital and basal portions (posterior to pterygoid laminae) of skull. Within the interior of the calvaria are fragments of bone which like this specimen appear to have been partially transformed into collophanite. Skull apparently evacuated of contents.

B. Blow delivered probably from the front upon back of skull.

3. 1326/3 A.D. Virtually complete skull (or, where this is absent, endocranial cast) with face and dentition of an adult male with right ascending ramus and crushed body of mandible and atlas bone attached. Type specimen of *Cercopithecoides williamsi*, Mollett, '46. See figure 11.

A. The left half of the skull is depressed (5-10 mm) below the right half posteriorly. A fracture runs transversely from a point slightly to the right of the sagittal suture in the mid-parietal region to another point a centimeter to the left of the suture and then backwards through the parietal and occipital bones to the left of the lambda and thence postero-inferiorly to the foramen magnum and forward through the skull base in the midline. The frontal bone was also fractured through the glabella and right supra-orbital ridge; and there is a depressed fracture (20 mm long) at the left parietal bone in the vicinity of the parieto-temporal suture. The complete longitudinal cracking and dislocation of the skull so produced has caused the palatal mid-line to form an angle of 10 degrees with the posterior part of the sagittal suture. No indication of evacuation of cranial contents.

B. An inward downward and forward blow delivered from the front over the left parieto-occipital region, dislocating the whole of the left side of the skull forward and to the right.

4. 1326/4 A.D. Virtually complete adult female skull, (and, where this is absent, endocranial cast) with face and upper jaw. Teeth broken off at sockets and mandible missing. The palatal length excludes this skull from the genus *Parapapio*; amongst the known types in this horizon at Makapansgat its affinities appear to be closest with *Papio darti*, Broom and Jenkins. See figure 6.

A. Extensive depressed fracture extending antero-posteriorly from the glabellar to the mid-parietal region and crushing the cranium (to the right of sagittal suture in the anterior parietal and posterior frontal region and in the center and medial half of the left frontal region) to a depth of 2 to 4 mm. The orbits have been fractured in both floor and roof, also the right side of the muzzle is missing over a considerable area. No indication of evacuation of cranial contents.

B. Violent direct downward blow delivered from the front with a double-headed object.

5. 1326 A.D. 5 A & B. Endocranial cast (5 A) fitting into an adult calvarial fragment (5 B) still *in situ* in breccia. The cast is deficient on the right side from the coronal suture to the occiput and an indentation (2-6 mm broad), apparently due to springing of the pterionic suture, separates the anterior extremity of the temporo-sphenoidal lobe and the lateral orbital portion of the frontal lobe from the rest of the endocranial cast. Cf., *Cercopithecoides williamsi*, Mollett.

A. The frontal portion of the sagittal sinus deviates 10 degrees leftward from the sagittal plane. A fracture line visible on both calvaria and cast runs diagonally antero-medially from central region of the right parietal bone towards the bregma. The right lateral border of cast is markedly elevated in the frontal and occipital regions showing that the bones of the side wall of the skull had been removed posterior to the pterionic region. Anterior thereto three fracture lines run towards the orbit and the comminuted state of the bone and the displacement leftwards of the whole frontal region indicate that the distorting impact was mainly received in this locality. The lateral part of the left frontal lobe and the anterior portion of the left temporo-sphenoidal lobe were also distorted by a fracture in that region.



B. A downward and inward blow delivered from the rear over the right fronto-orbital region.

6. 1326/6 A.D. Adult skull severed coronally from the muzzle just anterior to the orbits. Portion of right third molar just erupting attached to the retained palatal fragment. Endocranial cast exposed where the skull roof has been removed by blasting. Cf., *Cercopithecoides williamsi*, Mollett.

A. The right temporo-parietal suture is sprung. The right zygomatic arch, the right temporal and right lateral portion of the occipital bones are absent; as is also the petro-mastoid region of the left temporal bone. The infero-medial wall of the right orbit is missing and the orbital fossa communicates with the nasal cavity through a 15 mm gap; while the nasal cavity communicates with the maxillary antrum through a 20 mm gap.

B. A downward inward and backward blow delivered from the front over the right side of the face.

7. 1326/7 A.D. Juvenile skull severed coronally through the frontal and sphenoid bones at the posterior end of the orbital cavity. Endocranial cast exposed where bone has been removed by blasting. Cf., *Cercopithecoides williamsi*, Mollett.

A. Although the frontal lobes are deficient it is obvious from the depression of the right fronto-temporal region in the endocranial cast that the frontal region on the right side had been fractured. There was a slight springing of the coronal suture leftward from the bregma; and the sulci on the left side of the cast are more accentuated than those on the right side.

B. A downward and inward and backward blow delivered from the front over the right orbital region.

8. 1326/8 A.D. Juvenile fronto-parieto-occipital calvarial fragment.

A. Grossly distorted, the right parietal bone has been depressed (or pushed in) and has two fracture lines running antero-superiorly to meet the sagittal suture where there is a quadrangular deficiency (approx.  $4 \times 13 \times 13 \times 18$  mm) in the calvaria just behind the bregma. The fracture lines are continued across the left parietal bone into the sprung coronal suture to the point where another almost square deficiency ( $10 \times 12$  mm) occurs in the antero-lateral angle of the left parietal bone.

B. A downward and inward blow delivered from the rear in the right parietal region.

9. 1326 A.D. 9 A & B. An almost complete adult endocranial cast (9 A) covered in part by calvaria articulating with remaining parietal portion of calvaria (9 B) still lodged in breccial matrix. Sex indeterminate. ? *Cercopithecoides williamsi*, Mollett.

A. The bone is in a friable condition; but, irrespective of this, most of the occipital and right temporal bones have disappeared. The medial half of the right parietal bone had been fractured and depressed and a line of fracture runs to the temporo-parietal suture, which has been completely sprung. The lateral wall of the right and left orbits had been smashed in and the right orbital cavity displaced leftwards so as to lie under the sagittal suture.

B. A downward and inward blow delivered from the front on the right orbital region and muzzle.

10. 1326/10 A.D. (a) Piece of breccia containing left side and most of muzzle of an infant skull lacking its calvaria. Cf., *Cercopithecoides williamsi*, Mollett; and (b) within 30 mm distance the fronto-parietal portion of an infantile calvaria, overturned as though in the original position it assumed after removal from the infantile skull, to which it apparently belonged.

A. The skull fragment exhibits two deficiencies in the left temporal region. The calvarial fragment displays a sprung sagittal suture and a depressed fracture extending over the anterior half of the (fronto-parietal) fragment on the right side.



B. A downward blow delivered from the front over the right fronto-parietal region and removal of calvaria.

11. 1326/11 A.D. Fragment of left side of adult mandible containing second and third molar teeth. Sex indeterminable. ? *Parapapio broomi*, Jones. See figure 20.

A. Removal from skull and fragmentation of mandible.

B. No evidence.

12. 1326/12 A.D. Fragment of body of adult female mandible, right side, containing the two premolars and three molars in state of slight wear. ? *Parapapio broomi*, Jones. See figure 23.

A. Fracture through body in front of first premolar and behind third molar teeth.

B. No evidence.

13. 1326/13 A.D. Fragment of body of adult male mandible, left side, containing two premolars and three molars in state of moderate wear. ? *Parapapio broomi*, Jones. See figure 19.

A. Fractured through symphyseal region and through body behind third molar tooth.

B. No evidence.

14. 1326/14 A.D. Greatly distorted calvaria of an infant skull in which coronal and sagittal sutures are open; facial portion, if present originally, was removed during blasting. Species indeterminable. See figure 2.

A. The occipital and temporal bones and base of the skull have been removed, and the coronal and sagittal sutures widely separated. The anterior border of the right parietal overrides the posterior border of the frontal on the right side. There are linear depressions running antero-laterally in the right parietal region and the right half of the frontal bone, parallel to one another, each about 20 mm long and 5 mm broad and separated from one another by a distance of approximately 20 mm. All these bones (the two parietals and the frontal) were fractured before fossilization.

B. Blow by a double-headed object delivered from the front on right frontal and right parietal areas; and removal of skull base.

15. B.P.I. 22 M. Fragment of body and ramus of adult mandible left side containing three molars in state of moderate wear. Sex indeterminable. ? *Parapapio broomi*, Jones. See figure 24.

A. Fractured through junction of body and ramus.

B. No evidence.

*Fossil australopithecids from Taung, Sterkfontein, Kromdraai and Makapansgat*

1. *Australopithecus africanus*. Complete facial portion of skull articulating with an endocranial cast, which filled virtually the whole of the right side of the cranial cavity (and part of the left side in the frontal and parietal regions), but is deficient for the remainder of the left side of the cranial cavity (and that portion of the base which intervenes between the pterygoid laminae and the foramen magnum). A piece of bone, approximately half an inch square, lies free on the lime-encrusted left surface of the cast, showing that the skull must have been sufficiently lacking on the left side to have allowed of the entrance of this fragment into its cavity.

A. The coronal suture was sprung slightly to the right and left of the bregma. The irregularity of the cast in the left frontal region suggests that the bone suffered from a fracture laterally which extended posteriorly into this region. This supposition is consistent with the fact that the roof and lateral wall of the orbit were fractured. The left ramus of the mandible was broken and the right

temporal bone has disappeared. Apparently the fossil, though very little if at all distorted had suffered an extensive defect in the antero-lateral portion of its neural wall.

B. A lateral blow on the left fronto-temporal region of the skull.

2. *Plesianthropus transvaalensis* type 1. A fragmented skull (without mandible or much of face) and a fronto-parieto-temporal endocranial cast lacking the right parietal and occipital regions. The right maxilla, premaxilla and malar are fairly complete and little crushed; the left maxilla is better preserved but less complete. The base and the vault are sufficiently preserved to yield accurate reconstruction of the general cranial dimensions.

A. The general volume and shape of the endocranial cast have been altered by compression. The squashing of the cast is maximal anteriorly and the temporal height is estimated to be reduced by at least 1 cm by the left temporal bone overriding the parietal at their suture. The left temporal lobe tip was absent from the cast. Crushing and distortion is evident also in the chiasmatic and inferior frontal regions. The left temporal bone was so damaged that it was removed piecemeal.

B. A lateral blow on the left temporo-parietal region of the skull.

3. *Plesianthropus transvaalensis* type 2. Fronto-parieto-temporal endocranial cast. Left fronto-parietal region deficient and occipital region and base entirely absent. The frontal portion of the sagittal sutural line has been deflected more than 15 degrees to the right of the parietal portion of the sagittal suture.

A. The bregmatic angles of both parietal bones are the seat of two depressed fractures in the right parietal bone that hinge together on each side of an irregular line; the left margin of the fractured area follows roughly the sagittal suture. The lateral margins of the area are depressed: the right 12 mm and the left 4 mm below the remainder of the parietal bones. Running across these broken fragments and the frontal bones run radiating fracture lines to the left and right lateral orbital margins both of which were fractured transversely. Owing to the great distortion in the right Sylvian notch region the temporal bone overrode the parietal for a centimeter.

B. A vertical blow just behind and to the right of the bregma with a double-headed object.

4. *Plesianthropus transvaalensis* type 3. Parieto-occipital endocranial cast fractured (in blasting) horizontally through the occipital poles and coronally through the parietal region in the vicinity of the vertex.

A. Fragments of bone in the substance of the cast show that the skull must have been open in some region or other (as in the Taungs specimen). The sagittal and lambdoid sutures have both been sprung. In addition to minor fracture lines a major line of fracture runs completely across the cast through the parietal regions and skirting the anterior margin of the right parietal area fragment. The postero-medial portion of the left parietal area is depressed below the right parietal area at the sagittal suture and even more deeply below the antero-lateral portion of the bone both anteriorly and laterally.

B. A vertical blow slightly to the left of mid-parietal region with a bludgeon.

5. *Paranthropus robustus*. Side of upper face, zygomatic arch, sphenoid, temporal and portion of occipital bones of the left side and a plaster endocranial cast of the interior of the preserved portions.

A. Left parietal bone crushed into floor of skull under a piece of stone (? dolomite).

B. Vertical blow in the left parietal region with a rock.

6. *Australopithecus prometheus*. Occiput exhibiting major portion of occipital bone and posterior third of each parietal bone. Margins of bones jagged.

A. Separation from remainder by transverse shattering of the vertex and avulsion of the front and rear halves of the skull.

B. A severing transverse blow with bludgeon on the vertex and tearing apart of the front and back halves of the broken skull.

## A BIBLIOGRAPHY OF THE PHYSICAL ANTHROPOLOGY OF INDO-CHINA, 1938-1947

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During the war years a remarkable amount of work on the physical anthropology of the people of Indo-China was carried out and published in that country. Two important series were maintained in Hanoi: the *Bulletin de l'Institut Indochinois pour l'Étude de l'Homme* (IEEH) and the *Travaux de l'Institut Anatomique de la Faculté de Médecine de l'Indochine* (TIA). The first of these began in 1938 and is devoted to articles on both physical and cultural anthropology. Its latest issue is volume 6 published in 1944. The second series, which began in 1936 as the *Travaux de l'Institut Anatomique de l'École Supérieure de Médecine de l'Indochine*, changed to its present title with volume 7 in 1943. The two publications, concentrating chiefly on the Vietnamese (Annamites) of Tonkin, form an impressive body of work. One general work, *Les caractéristiques anthropo-biologiques des Indochinois* was published as volume 4 of the TIA. A third major source of published material on the people of this area is the body of theses of students at the Faculty of Medicine of the University at Hanoi. In the more purely medical field two periodicals which continued publication during the war years are: *Annales de l'École Supérieure de Médecine et de Pharmacie de l'Indochine* (AMPI) and *Revue Médicale Française d'Extrême-Orient*.

A two volume work of interest to both cultural and physical anthropologists is *Morphologie Humaine et Anatomie Artistique* by Huard and Do-Xuan-Hop published in Hanoi in 1942.

Special credit is due to Professor Huard of the Faculty of Medicine of the University at Hanoi who has not only done much of the research and writing in this field but has also trained and encouraged many Vietnamese students to do likewise. A number of these Vietnamese scholars are now with the resistance movement, but it is to be hoped that when peace returns to Indo-China they will be able to carry on the fine tradition of medical training and anthropological research instilled in them by Professor Huard and maintained by the strong scholarly traditions of Vietnamese culture.

In this bibliography an attempt has been made to list all articles written on the physical anthropology of Indo-China from 1938 to 1947 inclusive. Full information is not available for every title which accounts for the lack of page references for certain entries. For the period previous to 1938 there is a bibliography given in volume 2 of TIA, pp. 5-7 and pp. 185-218. Diacritical marks used in the romanization of Vietnamese names have been omitted since that omission does not affect the usefulness of the bibliography. Additions to and corrections of the following bibliography will be most welcome.

The bibliography is divided into the following categories:

#### RACIAL ANATOMY AND PHYSIOLOGY

- I. *General*
- II. *Craniology, osteology and the teeth*
- III. *Soft parts*
- IV. *Serology*
- V. *Immunology*

#### GROWTH AND NUTRITION

#### RACE MIXTURE

#### DEMOGRAPHY

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A COMMITTEE ON INTERRELATIONS OF PLEISTOCENE RESEARCH under the Division of Geology and Geography in the National Research Council was set up in June 1947 to furnish needed lateral coordination in this field. The committee, which includes among its members Loren C. Eiseley and Hallam L. Movius, Jr., representing New and Old World archeology respectively, held its first meeting in New Haven on April 5-6, 1948.

It has been pointed out that "The departmentalization of universities, museums, and government research institutions operates to keep many workers apart. Also, it inhibits the distribution of research funds outside the limits of conventional channels. The means of publication, likewise, are departmentalized, so that it is impossible for a worker interested in the whole field of the Pleistocene to cover the current literature in Pleistocene research or even to be aware of the existence of all of it."

PASSING OF OUR FOREIGN-BORN.—The foreign-born among us have been rapidly decreasing in number. While they now account for less than one-tenth of our total population, they currently contribute more than one-fifth to the total deaths of white persons. This situation is the result of two decades of almost complete cessation of immigration and the consequent attenuation of the younger age groups. The foreign-born are as a whole a rapidly ageing population . . .

It is extremely doubtful whether our country will open its doors to an influx of immigrants in the next few decades. Without such renewed immigration the foreign-born will rapidly pass from the American scene. The National Resources Planning Board has estimated that, without immigration, the foreign-born among us, who constituted less than 10% of our white population in 1940, will decrease to less than 5% by 1960, and to only 1% by 1980.—Statistical Bull., Metropolitan Life Ins. Co., vol. 26, no. 6, June, 1945, pp. 9-10.

MENARCHE AND FUNCTIONAL PERFORMANCES.—At puberty girls become stronger, their endurance deteriorates, while their sprinting performances remain virtually unchanged. In a variety of studies of physical development and muscular efficiency of girls, sexual maturation was found to cause incisive changes of progress patterns of growth or even a distinct reversal of trends, for example in regard to physical endurance. In 1937 Shuttleworth demonstrated the menarche rather than chronological age marks the onset of the above alterations of rate or direction of growth. Thus, the study of correlations between menarche and growth is of special interest to physical education, since it links up a well-analyzed field of applied physiology with an important chapter of experimental and clinical endocrinology.—E. Jokl, Menarche, growth and physical efficiency. *Nature*, vol. 157, no. 3981, 1946, pp. 195-196.



## THE FEMUR OF PLESIANTHROPUS TRANSVAALENSIS

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### FIVE FIGURES

Among the fossil bones found at Sterkfontein, South Africa, from 1936 onward, is the well-preserved lower end of a left femur that lacks only a flake from its lateral aspect. This bone has been attributed to the extinct Australopithecine primate, *Plesianthropus transvaalensis*, of which skulls have been recovered at the same locality. It was briefly described by Broom (in Broom and Schepers, '46) and has been more fully discussed by Le Gros Clark ('47a, '47b).

Both Broom and Le Gros Clark have stressed the essentially manlike nature of this femoral fragment, which is quite small for that of a man yet within the size range of the Bushman femur (Le Gros Clark, '47b). Largely because of its presumed peculiarly hominid characters, both of these investigators have concluded that this bone belonged to an animal that was capable of standing and walking in the erect posture.

According to Broom, "The fragment is so remarkably similar to that of man that doubtless some will be of the opinion that it is probably human . . . The fragment agrees in most characters with the femur of a small human being such as a Bushman; and probably some anatomists will affirm that this is a fragment of a human femur. Being a small femur it does not resemble very greatly those of the larger male types, but the resemblance to that of the female Bushman is considerable. There are, however, one or two characters in which it differs

not only from the Bush femur, but from all other human femora which I have examined [intercondyloid notch and medial condyle, *vide infra*] . . . One thing is, I think, quite certain, the femur is that of an animal that walked, as does man, entirely or almost entirely on its hind feet" (p. 73).

Le Gros Clark stated in his first paper that "The lower end of the femur of *Plesianthropus*, if considered entirely isolated from the circumstances of its discovery, would probably be referred by most anatomists to *Homo sapiens* . . . The important inference to be drawn from a comparative study of the femur is that its owner must have been capable of standing and walking in the erect position somewhat as modern Man does" ('47a, p. 392). In his second paper, he went on to say that "In its anatomical details . . . the bone shows a resemblance to the femur of *Homo* which is so close as to amount to practical identity . . . A survey of the anatomical details of the *Plesianthropus* femur . . . will make it quite clear that the bone is constructed almost entirely on the human plan. In other words it is mechanically adapted for standing, walking and running in the erect position. It thus offers a complete contrast to the femur of the modern anthropoid apes" ('47b, pp. 327-330).

That the fragmentary femur of *Plesianthropus* in general strongly resembles the corresponding part of that bone in man and differs markedly from those of the anthropoid apes, is not to be contested. The descriptions and illustrations of Broom and Le Gros Clark amply affirm this conclusion. But it remains to be proven that the characters that it displays are peculiarly and exclusively hominid, and that such characters are necessarily indicative of ability to assume and maintain an erect, bipedal posture. While engaged in a comparative study of the femur, we have noted that in a number of points the *Plesianthropus* fragment is remarkably similar to the femora of Old World monkeys, an observation which has caused us to question the validity of the conclusions of Broom and Le Gros Clark. Neither of these workers seems to have included the monkeys within the scope of his investigations but rather to

have limited his comparative studies to man and the anthropoids, particularly the great apes. A careful reconsideration of the nature of the Sterkfontein femur is therefore indicated. Unfortunately, no cast of this specimen is available to us for study. In Le Gros Clark's second paper ('47b), however, there are sufficient data on several important points to enable us to make comparisons with our own observations on series of extant catarrhines — including man, anthropoid apes and monkeys — and thereby to assess the taxonomic and functional significance of the major features of the fossil bone. Le Gros Clark deals especially with 5 femoral characters, which will be discussed below.

We wish to thank Dr. T. D. Stewart, Division of Physical Anthropology, and Dr. Remington Kellogg, Division of Mammals, U. S. National Museum, for the opportunity of studying human and other primate femora. Other material used in this investigation belongs to the collections in the Department of Anatomy, The Johns Hopkins University School of Medicine. Only adult specimens have been used.

#### OBSERVATIONS

*Robustness of the femoral shaft.* Le Gros Clark ('47b) has pointed out that although the *Plesianthropus* femur is a comparatively small bone, it is robust, the lower end of the shaft being, relative to the bicondylar width, "more robust than in the chimpanzee, European child, or Bushman."

For the fossil, he gave the bicondylar width as 56.5 mm (taken by the method of Parsons, '14) and the shaft width as 32 mm (taken "at a distance of 6.5 cm from the level of the tibial articular surfaces"). From these measurements, an index of shaft robustness ( $\frac{\text{shaft width} \times 100}{\text{bicondylar width}}$ ) can be calculated. For *Plesianthropus* this index is thus 56.6 (cf. fig. 1).

In our material, the bicondylar width has been measured by a different but essentially comparable method (see Pearson and Bell, '19, plate 2 B and text, [S] p. 17). When measuring the shaft width, it is obviously necessary that it be done at a

point comparable to that used by Le Gros Clark in *Plesianthropus*. This has been determined in the following manner: The width of the *Plesianthropus* femur 65 mm above the standard horizontal plane is 32 mm, and the bicondylar width is 56.5 mm (Le Gros Clark). The height at which shaft width was measured is thus 1.15 times the bicondylar width ( $\frac{65}{56.5} = 1.15$ ). In all femora that we have studied the shaft width was therefore measured parallel to the standard horizontal plane at a height  $1.15 \times$  bicondylar width above this plane. The summarized robustness indices are given in table 1.

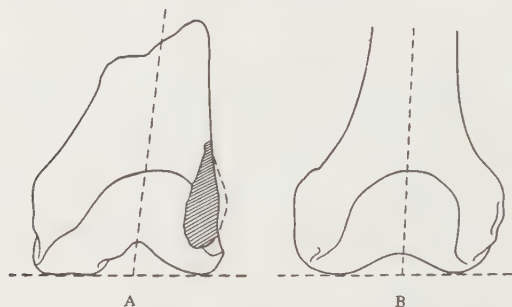


Fig. 1 The lower end of the left femur of *Plesianthropus* (A) and that of an adult chimpanzee (B), seen from in front. (After Le Gros Clark, '47b.)

Our observations confirm the statement of Le Gros Clark that the shaft of the *Plesianthropus* femur is relatively more robust than the shafts of the femora of man and the anthropoid apes. They demonstrate, moreover, that as far as robustness is concerned, the fossil femur is not unique but finds its counterpart among the Old World monkeys. In other words, its high degree of robustness is a cercopithecoid or monkey-like character rather than an anthropoid or a hominid character. The robustness index of *Plesianthropus* (56.6) is larger than the average indices obtained for all monkey genera studied except *Erythrocebus* and consequently is above the average value of the combined series of Cercopithecidae (52.6). Yet it is equalled or surpassed in 7 (19%) of our monkey femora: *Macaca sinicus*, 56.6; *Cercopithecus callitrichus*, 57.1; *Semno-*



*pithecus entellus*, 57.9; *Papio sphinx*, 58.7; *Macaca sylvanus*, 59.7; *M. sinicus*, 60.0; *Erythrocebus patas*, 62.9. Whereas among the Cercopithecidae the robustness index is usually greater than 50 (of the 37 indices secured, 29 or 78% have val-

TABLE 1

*Robustness index of the lower part of the femoral shaft*  $\frac{\text{shaft width} \times 100}{\text{bicondylar width}}$  *in Plesianthropus and extant catarrhine primates. The value for Plesianthropus has been calculated from measurements given by Le Gros Clark ('47b, p. 327). The human series is composed of 22 Whites (U. S.), 15 Eskimoes, 2 Negroes (U. S.), 7 Kaffirs, and 12 Australians*

PRIMATE	NO. OF SPECIMENS	AVE. $\pm$ S.E.	RANGE	$\sigma \pm$ S.E.
Plesianthropus	1	56.6		
Man	58	44.9 $\pm$ 0.62	(35.2-58.8)	4.72 $\pm$ 0.43
Great apes:				
Gorilla	31	45.4 $\pm$ 0.49	(39.6-51.4)	2.73 $\pm$ 0.34
Chimpanzee	14	40.2 $\pm$ 0.55	(37.1-44.6)	2.09 $\pm$ 0.39
Orang-utan	28	42.0 $\pm$ 0.73	(32.5-49.3)	3.87 $\pm$ 0.51
Hylobatidae:				
Symphalangus	3	44.4	(43.8-45.2)	
Hylobates	3	41.9	(40.7-44.4)	
Cercopithecidae:				
Macaca	17	52.8 $\pm$ 0.90	(46.8-60.0)	3.74 $\pm$ 0.64
Papio	6	51.1	(45.7-58.7)	
Theropithecus	1	48.0		
Cercocebus	3	51.2	(50.0-52.0)	
Cercopithecus	5	52.3	(46.2-57.1)	
Erythrocebus	2	58.0	(53.1, 62.9)	
Semnopithecus	2	55.9	(53.8, 57.9)	
Nasalis	1	52.8		

ues of 50 units or more and 23 or 62% have values beyond 50 units), it is normally somewhat below 50 in man and the anthropoid apes. Indeed, in our series of the latter animals, it only once attains 50 (in a male gorilla, with index of 51.4). In man, although the index of robustness is on an average no

larger than that of the gorilla, it is much more variable.<sup>1</sup> Hence a few human femora actually surpass that of *Plesianthropus* in robustness (White males, 56.8, 58.7, 58.8); in our experience, however, a high index is exceptional, for among our 58 men it is 50 or above in but 6 instances (10%).

A high index of robustness cannot be a mere reflection of general femoral smallness, as witness the relatively low indices of the Hylobatidae. Furthermore, Pearson and Bell give photographs of the femora of Bushmen and Andaman Islanders from which the robustness indices can be determined with a fair approximation of accuracy; in all of these, the index obviously lies below 50. Likewise, Le Gros Clark ('47b) stated that a Bushman femur, measured by him, had a bicondylar width of 53 mm and a shaft width of 24.5 mm, which yields an index of only 46.2.

It can be concluded, therefore, that in its high degree of relative shaft robustness the *Plesianthropus* femur distinctly resembles that of the average cercopithecoid monkey and differs from that of the average man or anthropoid ape.

*Obliquity of the femoral shaft.* Le Gros Clark ('47b) has pointed out that the obliquity of the shaft in the *Plesianthropus* femur, "that is to say the angle between the axis of the shaft and the vertical axis in the standing position . . . can be approximately estimated by placing the tibial articular surfaces on a flat surface and measuring the angle of inclination of the axial line extending from the center of the preserved part of the shaft to the mid-point of the anterior end of the inter-condylar notch," and that by this method "the angle of obliquity is at least 7°" (see fig. 1). He stated, furthermore, that whereas this angle "makes a strong contrast

<sup>1</sup>There is no statistically significant difference between the means of man and gorilla nor between those of chimpanzee and orang-utan; but the differences between the mean of man and those of chimpanzee and orang, between the mean of gorilla and those of chimpanzee and orang, and between the mean of macaque and those of gorilla, chimpanzee, orang and man are all statistically significant. The differences between the corresponding standard deviations are not significant except in the instances of man-gorilla, man-chimpanzee, chimpanzee-orang, and possibly macaque-chimpanzee.

with that of the femora of modern anthropoid apes" it falls well within the range of the angle for normal human bones. In this statement, he was relying upon the data of Pearson and Bell for the African anthropoids (average angle,  $1.8^{\circ}$  in gorilla and  $-0.1^{\circ}$  in chimpanzee) and those of Parsons for man (average angle  $10^{\circ}$ , range  $4^{\circ}$ – $17^{\circ}$ , in English males). Consequently, he believed that "it may be inferred, therefore, that in the erect standing position adopted by *Plesianthropus* the femur sloped downwards and medially as in man."

The inference in this is that a relatively large angle of obliquity or inclination, as for instance of  $7^{\circ}$ , is, among the catarrhines at least, peculiar to man and hence of necessity associated with an erect posture. One might, indeed, arrive at such a conclusion if he confines his attention to the averages for the anthropoid apes given by Pearson and Bell (p. 319: gibbon,  $3.0^{\circ}$ ; orang,  $5.2^{\circ}$ ; gorilla,  $1.83^{\circ}$ ; chimpanzee,  $-0.1^{\circ}$ ). But the results of our own studies of femoral obliquity do not entirely agree with those of Pearson and Bell, although like them we have used the entire shaft, so that our results are essentially comparable. All measurements of this angle were taken with the bone in the standard vertical position as described by them (P. & B., p. 23). The obliquity of the shaft is "the angle between the perpendicular to the standard horizontal plane and the projection of the axis of the shaft on the standard vertical plane" (P. & B., p. 30). Since the axis of the femur is frequently a curved line it must be estimated, either visually or by having it pass through as many of the center points of the shaft as possible (Walmsley, '33, p. 285, footnote 4). Workers in general have used the midcondylar point (i.e. the highest point on the intercondyloid notch) as one of the reference points for the axis.

The average values that we have thus obtained for the two African anthropoids are appreciably larger than those given by Pearson and Bell, and that for the orang-utan is somewhat smaller (K. & S. — gorilla, 28 femora: ave.  $4.4^{\circ}$ , range  $-0.1^{\circ}$  to  $9.1^{\circ}$ ; chimpanzee, 11 femora: ave.  $3.4^{\circ}$ , range  $0^{\circ}$  to  $5.9^{\circ}$ ;

orang, 24 femora, ave.  $3.8^\circ$ , range —  $0.8^\circ$  to  $7.4^\circ$ ). These discrepancies are undoubtedly to be explained by the fact that the series studied by Pearson and Bell were very much smaller in size than our own (gorilla: P. & B. 7, K. & S. 28; chimpanzee, P. & B. 2, K. & S. 11; orang, P. & B. 5, K. & S. 24). Among our animals, specimens having an angle equal to or greater than that of *Plesianthropus* occur in both the gorilla and the orangutan, although they are uncommon (angle of  $7^\circ$  or more: gorilla, 2 of 28, or 7%; orang, 2 of 24, or 8%; chimpanzee, 0 of 11, or 0%). In contrast, among our 61 human femora, with an average angle of  $8.1^\circ$  ( $2.0^\circ$  —  $14.6^\circ$ ), an angle of  $7^\circ$  or more is the rule (in 51, or 84%).

The *Plesianthropus* femur, however, comprises only a short fragment of the distal shaft. Strictly to compare its angle with those taken on extant primates, it is necessary, in the latter specimens, to study only the comparable portion of the femur. This has been arrived at by measuring a second angle of obliquity that includes only that part of the lower shaft up to a point 1.15 times the bicondylar width, as described earlier in this paper. The axis of the femur, following Le Gros Clark ('47b, p. 327), has been considered to be a line connecting the midpoint of the shaft diameter at this height and the midcondylar point. It should be noted that this angle of obliquity, which is based upon only the lower part of the shaft, is not always of the same value as the angle secured by the method of Pearson and Bell, which uses the entire bone. In some femora, the values secured by the two methods are identical, but in most instances they differ (sometimes by as much as  $4^\circ \pm$ ). These discrepancies result from lateral or medial bowing of the femur.

Using only the lower portion of the shaft and studying precisely the same material in which the obliquity of the entire shaft was measured, we have secured the angles of obliquity given in table 2. It will be noted that the anthropoid averages are all larger than those secured when using the entire shaft,



whereas the human average is smaller.<sup>2</sup> This probably means that the upper portion of the shaft is differently bowed in anthropoids than in man.

When only the lower part of the femur is used, the values obtained for the anthropoids and man thus exhibit a greater degree of overlapping than when the whole shaft is included. Hence anthropoid values equal to or greater than that of *Plesianthropus* occur among all of the great apes, being especially frequent in the gorilla (angle of  $7^\circ$  or more: gorilla, 9 of 28, or 32%; chimpanzee, 1 of 11, or 9%; orang, 2 of 24, or 8%). Among the human femora, such an angle occurs in 61% (37 of 61). Hence, when truly comparable methods are used, *Plesianthropus* herein does not appear as exclusively hominid and non-anthropoid as Le Gros Clark was led to believe.

In the cercopithecoid monkeys, by contrast, the angle is regularly small (see table 2). Of the 17 that we have measured, it approaches the *Plesianthropus* angle in only a single specimen (*a Cercopithecus pygerythra* with an angle of  $6.5^\circ$ ). None of the remaining 16 monkeys has an angle of more than  $3.9^\circ$ .<sup>3</sup> The angles of our 4 examples of Hylobatidae suggest a closer resemblance to the great apes than to the monkeys.

In any event, the value of the obliquity angle found in *Plesianthropus* is not peculiarly hominid, for it can be matched in all of the great anthropoid apes. Indeed, it is of an order that is especially common in gorillas. Hence, it must be obviously

<sup>2</sup> The difference between the human mean and those of gorilla, chimpanzee and orang are all statistically significant, as is the difference between the means of gorilla and orang. The gorilla-chimpanzee difference is possibly statistically significant, whereas the chimpanzee-orang difference is not. None of the differences between the respective standard deviations is statistically significant.

<sup>3</sup> It should be noted that the averages of the angle of obliquity given by Pearson and Bell ('19) for Old World monkeys ("Simiadae") in table 19 (p. 319), and which range from  $6.25^\circ$  to  $7.3^\circ$ , are all incorrect. They are in striking disagreement with the much lower values given by the same authors in table 3, General Summary, etc. (opposite p. 485) and in table 1, Atlas, which are very similar to our own. The values erroneously listed in table 19 are actually the values secured by Pearson and Bell for the midtrochlear angle (see table 20, p. 321; table 3, General Summary, etc., and table 1, Atlas). This *lapsus calami* is undoubtedly responsible for the conclusion of these authors that in femoral shaft obliquity the Old World monkeys are nearer to recent man than are the anthropoids.

concluded that a relatively high angle of obliquity is of no great diagnostic value and is certainly no index of an erect, bipedal posture.

*Contour of the patellar surface.* Le Gros Clark ('47b) claimed that the morphology of the patellar surface of the *Plesianthropus* femur supports his conclusion that, in life, the

TABLE 2

*Angle of obliquity of the lower part of the femoral shaft in Plesianthropus and extant catarrhine primates. The value for Plesianthropus is after Le Gros Clark ('47b, p. 327). The human series is composed of 25 Whites (U. S.), 15 Eskimos, 2 Negroes (U. S.), 7 Kaffirs, and 12 Australians*

PRIMATE	NO. OF SPECIMENS	AVE. $\pm$ S.E.	RANGE	$\sigma \pm$ S.E.
		<i>degrees</i>	<i>degrees</i>	
Plesianthropus	1	7.0		
Man	61	7.5 $\pm$ 0.27	(1.6-14.9)	2.12 $\pm$ 0.19
Great apes:				
Gorilla	28	6.0 $\pm$ 0.44	(2.4-11.2)	2.33 $\pm$ 0.31
Chimpanzee	11	4.4 $\pm$ 0.56	(0 - 7.2)	1.88 $\pm$ 0.40
Orang-utan	24	4.0 $\pm$ 0.43	(-0.8- + 8.0)	2.15 $\pm$ 0.31
Hylobatidae:				
Symphalangus	2	4.2	(2.9, 5.4)	
Hylobates	2	4.9	(4.1, 5.6)	
Cercopithecidae:				
Macaca	5	0.9	(0.1- 2.0)	
Papio	2	2.0	(0.9, 3.0)	
Cerecocebus	4	2.1	(1.2- 3.9)	
Cercopithecus	5	2.0	(-0.5- + 6.5)	
Semnopithecus	1	0.1		

bone was oriented as in man, pointing out that "while in the anthropoid apes this surface is broad, shallow, and evenly curved, thus permitting considerable freedom of lateral movement between the patella and the femur, in *Plesianthropus* it is relatively deeper, and laterally slopes rather abruptly into a prominent lip. It should be mentioned that the summit of this lip is actually missing in the fossil bone, but its position can be reconstructed with fair accuracy" (fig. 2).

But, in the possession of a patellar surface that is curved so as to form a true fossa, of which the lateral border or lip is higher than the medial lip, *Plesianthropus* does not, as Le Gros Clark intimated, exhibit a character that is peculiarly hominid. For not only in man but also in the various genera of Old World monkeys the patellar surface regularly forms a relatively deep fossa of which the lateral lip is distinctly higher than the medial one (fig. 3, C, D, E). We have encountered one or two individual femora of cercopithecids among the many that we examined in which the lips were of approximately equal height, but we have never seen an Old World monkey femur in which the medial lip was the more prominent one.

In all three of the great anthropoid apes, however, the patellar surface is regularly almost flat, with little or no indication

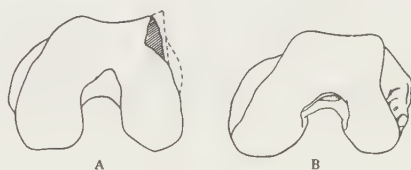


Fig. 2 The lower end of the left femur of *Plesianthropus* (A) and that of an adult chimpanzee (B), seen from below. (After Le Gros Clark, '47b.)

of a fossa. The "lips" are either of about equal height or else the surface, as seen from below, slopes upward medially, so that its "medial lip" is the higher (fig. 3, A, B). This is in direct contrast with the morphology of this region in man and the Cercopithecidae, in which the surface regularly slopes upward laterally in conformity with the higher lateral lip (also see Boule, '11-'13). The contour of the patellar surface in the Hylobatidae seems to be quite variable and to a certain extent intermediate between that of the great apes and that of the Old World monkeys and man. In the siamang (*Symphalangus*), it may be flat (so that there is no fossa) but with a slight lateral inclination upward; or a fossa is lacking, but the upward slope is medial, so that the medial "lip" is the higher; or a fossa is present, the medial lip being the higher.

In the gibbon (*Hylobates*), where there is usually a shallow fossa, the two lips may be of about equal height or the lateral one may predominate.

In view of the above observations, it may be concluded that neither the degree of curvature of the patellar surface nor the relative heights of its lips is of deep diagnostic value. Nor can they be correlated with posture.

*The intercondyloid notch.* Broom wrote of the Sterkfontein femur that "The intercondyloid fossa passes more forward towards the patellar articular surface than in the human femur. I have examined the femora of over a hundred Kafirs, Europeans, Bushmen, Amerinds and Australians, and cannot find in any of them a similar forward extension of the

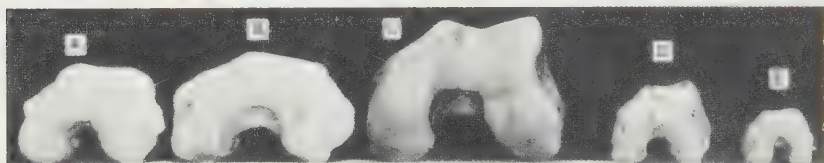


Fig. 3 The lower ends of the left femora of chimpanzee (A), gorilla (B), man (C), baboon, *Papio sphinx* (D), and rhesus monkey, *Macaca mulatta* (E), oriented in the standard vertical position, seen from below. All specimens are adult.

intercondyloid fossa. Possibly if I could have examined a thousand human femora of different races I might have discovered one with this peculiarity. But certainly it is a very rare condition in man, if it ever occurs. Then the fossa invades the external condylar articular surface much more than I can find in any human femur."

Le Gros Clark ('47a) also stated that "the intercondylar notch is prolonged forwards to an unusual extent, in association with an exaggerated impression related to the anterior cruciate ligament, and it has not been possible, so far, to match this curious feature in modern human races." He added, later ('47b): "If the condyles are viewed from below and compared with those of the modern anthropoid apes . . . the contrast is striking. The shape and disposition of the condyles



are again typically human, and are separated by a relatively narrow intercondyloid notch. The latter is prolonged forwards to an unusual extent, and at its anterior end presents a notch which is an exaggeration of a similar notch often to be observed in human femora. This notch, as pointed out by Siddiqi ('34), is related to the pressure of the anterior cruciate liga-

TABLE 3

*Relative height of the intercondyloid notch  $\frac{N \times 100}{P}$  in Plesianthropus and extant catarrhine primates. The value for Plesianthropus has been calculated from measurements taken on a drawing of Le Gros Clark ('47b, text-fig. 12A). The human series contains both Whites (U. S.) and Negroes (U. S.)*

PRIMATE	NO. OF SPECIMENS	AVE. $\pm$ S.E.	RANGE	$\sigma \pm$ S.E.
Plesianthropus	1	64.0		
Man	11	56.6 $\pm$ 1.40	(47.6-64.2)	4.65 $\pm$ 0.99
Great apes:				
Gorilla	8	57.7	(53.2-61.3)	
Chimpanzee	8	54.2	(45.8-59.0)	
Orang-utan	10	56.4 $\pm$ 1.83	(46.6-65.1)	5.79 $\pm$ 1.29
Hylobatidae:				
Symphalangus	5	52.9	(47.7-58.1)	
Hylobates	4	51.1	(48.7-54.3)	
Cercopithecidae:				
Macaca	13	44.9 $\pm$ 1.30	(38.1-52.2)	4.71 $\pm$ 0.92
Papio	6	50.0	(45.6-58.1)	
Cercocebus	3	46.4	(44.7-47.4)	
Cercopithecus	5	47.0	(45.7-52.4)	
Semnopithecus	2	45.8	(45.8, 45.8)	

ment of the knee joint in full extension, and appears to indicate, therefore, that the joint could be habitually sustained in this typically human position in *Plesianthropus*" (see fig. 2).

From the illustrations of both Broom and Le Gros Clark, it is obvious that the notch of the fossil bone is remarkably deep or high. It is difficult, however, to compare its development with the notches of existing catarrhines, for no measurement

of it, either absolute or relative, is given by either author. Some approximate comparisons seem nevertheless justifiable. In his text-figure 12 (fig. 2), Le Gros Clark ('47b) shows the distal end of the fossil bone, evidently oriented so as to lie in the standard vertical position or plane described by Pearson and Bell (in which the femur rests upon the posterior surfaces of its condyles and intertrochanteric ridge) — in so far as that orientation can be approximated in a femoral fragment like

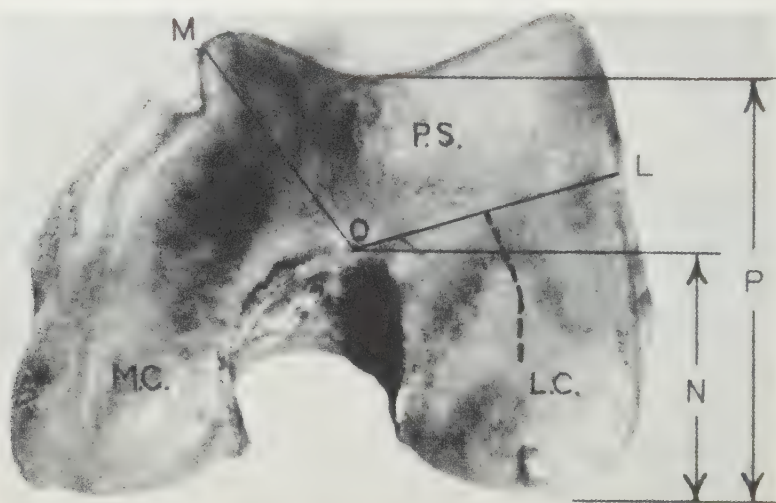


Fig. 4 The lower end of a left human femur oriented in the standard vertical position, seen from below, to illustrate the methods of measuring the height of the intercondyloid notch (N), the height of the patellar surface (P), and the "weight-bearing" or tibial areas of the medial (MC) and lateral condyles (LC). For details, see text.

that of *Plesianthropus*. With the bone in this position the height of the intercondyloid notch can be measured as a perpendicular projection from its highest or most anterior point downward to the standard vertical plane on which the condyles rest (fig. 4, measurement N, point O representing the most anterior point on the border of the notch). The height of the patellar surface of the femur can also be measured as a similar perpendicular projection from the deepest point of the

patellar fossa, or lacking a fossa, from the midpoint along the upper border of the patellar surface (fig. 4, measurement P). Relative notch height is calculated by the index  $\frac{N \times 100}{P}$ . We recognize that this is undoubtedly not the best way to determine the relative depth of the notch, but lacking access to the original *Plesianthropus* femur or to a cast, and having necessarily to rely upon published drawings, it is the only method by which we are able to compare the notch of the fossil with those of present-day primates.

Using Le Gros Clark's text-figure 12 (fig. 2), the relative height of the notch is approximately 64.0 in *Plesianthropus*. It may be immediately noted that among the femora of primates that we have measured, only 2 specimens show an index as high or higher than the index of the fossil bone (a man with index of 64.2, and an orang with an index of 65.1). According to our series, the average value of this index is appreciably and equally smaller than that of *Plesianthropus* in man, gorilla and orang-utan, still lower in chimpanzee and Hylobatidae, and smallest of all in the cercopithecoid monkeys (see table 3).<sup>4</sup> It is thus apparent, despite the limitations of our method, that *Plesianthropus* possesses an extraordinarily high notch, but one that is probably within the variation ranges of both man and great apes although far outside the ranges of the cercopithecoid monkeys. In the absence of an adequate cast, however, we prefer not to be dogmatic.

The extreme antero-lateral prolongation of the notch, so as to form a sort of secondary notch — which has impressed both Broom and Le Gros Clark — is an uncommon feature in extant catarrhines. Le Gros Clark regarded it as an exaggeration of a feature often found in man and related according to Siddiqi ('34) to pressure from the anterior cruciate ligament during full extension of the knee. From this, he concluded that the knee of *Plesianthropus* "could be habitually sustained in this

<sup>4</sup> The difference between the means of man and orang is not statistically significant, but those between the means of macaque and man and macaque and orang are significant. None of the differences between the respective standard deviations is significant.

typically human position." Siddiqi's description and illustration of this secondary notch are not entirely clear. If we interpret him correctly, however, we have seen such a structure not only in man but in other primates as well — in at least occasional anthropoid apes and cercopithecoid monkeys, as well as in a femur of the squirrel monkey, *Saimiri oerstedii*, a platyrrhine. It remains to be proven that its occurrence is necessarily always correlated with pressure from the anterior cruciate ligament and with complete extension of the knee.

The general shape of the notch varies greatly, both intragenerically and intraspecifically (cf. figs. 3C and 4). It tends, however, to be relatively narrower, with more parallel sides, and its top to be more pointed (so that it approaches a Gothic arch) in both man and Cercopithecidae than in the anthropoid apes (in which its usually rounded top approximates that of a Romanesque arch). Herein *Plesianthropus* appears to exhibit a hominid and cercopithecoid rather than an anthropoid character.

*Relative sizes of the femoral condyles.* Le Gros Clark ('47b) wrote: "A comparison of views of the posterior aspect of the fossil femur and that of the chimpanzee serves to emphasize another interesting point. In the modern anthropoid apes, the load line of the body in the standing position passes through or medial to the medial condyle of the femur (Walmsley, 1933). In relation to this fact the medial condyle presents a much larger articular surface than the lateral condyle. In modern man, the load line in the erect standing position (with the knees together) passes through the lateral condyle which thus becomes more important for weight bearing; in the human femur, therefore, the medial condylar articular surface is relatively less strongly developed. In the *Plesianthropus* femur, the proportionate sizes of the two condyles are quite similar to those of *Homo*" (see fig. 5). Broom, however, has noted that in *Plesianthropus* "The anterior part of the articular surface of the inner condyle is better developed relatively than in most human femora; though this may not be a matter of much importance. Still it is interesting to note that this



is a chimpanzee and orang, rather than a human character."

There would seem to be some discrepancy here, a discrepancy likely explicable at least in part by the fact that—in our experience—visual estimation of the relative sizes of the condylar articular surfaces can be extremely delusive. Accurate comparison of the articular areas of the two condyles necessarily involves their measurement with some degree of accuracy and precision. To our knowledge, this has hitherto not been done. Pearson and Bell ('19) compared the maximum anterior-posterior lengths of the two condyles in man and other primates, and Walmsley ('33) recorded their widths in modern man, Neanderthal man, *Pithecanthropus*, and gorilla. Both of

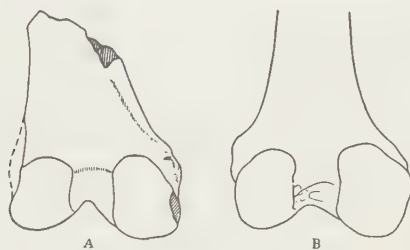


Fig. 5 The lower end of the left femur of *Plesianthropus* (A) and that of an adult chimpanzee (B), seen from behind. (After Le Gros Clark, '47b.)

these methods yield at best only crude approximations of the sizes of the condylar articular areas.

When comparing the articular areas of the lateral and medial condyles of the femur, particularly with posture or potential weight bearing in mind, it is necessary to exclude that portion of the articular surface which makes contact only with the patella and which is never concerned with weight bearing. Since the boundary between the patellar and the tibial or "weight-bearing" surfaces is usually obscure or arbitrary in ordinary museum material, we have devised a procedure by which this boundary can be at least approximated and which can be reproduced by other investigators. The following refers to figure 4. From O, the most anterior point on the

intercondyloid notch, lines OL and OM are drawn perpendicular to the two midcondylar axes (dashed lines) determined by visual inspection. The portion of the articular surface anterior to lines OL and OM is considered to be the patellar surface (PS), whereas the portions posterior to these lines are regarded as the tibial or "weight-bearing" surfaces of the lateral (LC) and medial condyles (MC), respectively. The latter surfaces have some contact with the patella when the knee is flexed, but they have "weight-bearing" or tibial relations during extension.

To measure the tibial areas of the condyles, the end of the bone is dipped into a molding jelly, Korogel (Buffalo Dental Mfg. Co., Buffalo, N. Y.), heated to 275° F. After cooling, this jelly forms a transparent, rubber-like film exactly duplicating the size and shape of the bone. The excess jelly is cut away from the borders of the condylar articular areas with a sharp knife, leaving only the portion covering the tibial surfaces — an easy procedure in view of the jelly's transparency. The remaining pieces of jelly are then peeled from the bone, flattened and outlined upon a piece of drawing paper and their areas measured (with a polar planimeter or by using square millimeter paper). Some error is undoubtedly introduced when the curved surface of Korogel is flattened, but this error is negligible when compared with the total area measured and in view of the error inherent in any procedure of this sort. The results secured by this method are given in table 4, in which we have expressed the size of the lateral condyle, relative to that of the medial condyle, by the index  $\frac{\text{tibial area of lateral condyle} \times 100}{\text{tibial area of medial condyle}}$ .

Even granting the correctness of Le Gros Clark's unsupported statement that in the femur of *Plesianthropus* the relative sizes of the two condyles are quite similar to those of man and contrast with the relative sizes in anthropoid apes, and ignoring Broom's inference to the contrary, it may be asked, "What is the significance, particularly respecting posture, of a relatively large lateral condyle?" Le Gros Clark implied that it is a peculiarly hominid character, indicative of lateral load bearing and hence of an erect, bipedal posture. But our

investigations definitely show that whereas a relatively *small* lateral condyle is characteristic of the great anthropoid apes, a relatively *large* lateral condyle is common to *both* erect, bipedal man and the pronograde quadrupedal cercopithecoid monkeys (table 4). It is of interest to note that Boule ('11-'13) arrived at essentially the same conclusion, based, presumably, upon visual estimation of condylar size.

TABLE 4

*Relative size of the "weight-bearing" or tibial surface of the lateral condyle of the femur  $\frac{\text{tibial area of lateral condyle} \times 100}{\text{tibial area of medial condyle}}$  in extant catarrhine primates. The human series contains both Whites (U. S.) and Negroes (U. S.)*

PRIMATE	NO. OF SPECIMENS	AVE. $\pm$ S.E.	RANGE	$\sigma \pm$ S.E.
Man	12	95.3 $\pm$ 2.64	(80.6-108.6)	9.16 $\pm$ 1.87
Great apes:				
Gorilla	7	57.7	(50.0- 64.4)	
Chimpanzee	9	65.9	(52.3- 74.3)	
Orang-utan	5	70.9	(56.3- 90.9)	
Hylobatidae:				
Symphalangus	1	87.9		
Hylobates	1	80.0		
Cercopithecidae:				
Macaca	8	90.7	(79.8-105.3)	
Papio	3	76.6	(70.0- 80.6)	
Erythrocebus	2	96.4	(90.0, 102.8)	
Semnopithecus	2	77.5	(73.5, 81.4)	
Nasalis	1	80.0		

In man, 4 of the 12 individual indices are 100.0 or more, three are in the range 90.0-99.9, and 5 lie within 80.0-89.9. Of the 21 great apes, only one (a female orang) exceeds 74.3; of the remaining 20, 4 (3 chimpanzees, 1 orang), lie within the range 70.0-79.9, 8 (4 chimpanzees, 2 gorillas, 2 orangs) within 60.0-69.9, and 8 (5 gorillas, 2 chimpanzees, 1 orang) within 50.0-59.9. Thus, except, for the single, wholly aberrant orang-utan, the distribution of this index in the great anthropoids is widely separated from that in man. In the Cercopithecidae, however,

the distribution differs strikingly from that of the great apes and approaches that of man; of the 16 indices, 3 (2 *Macaca*, 1 *Erythrocebus*) are 100.0 or more, 3 (2 *Macaca*, 1 *Erythrocebus*) are within the range 90.0–99.9, 6 (3 *Macaca*, 1 *Papio*, 1 *Semnopithecus*, 1 *Nasalis*) are within 80.0–89.9, and 4 (2 *Papio*, 1 *Macaca*, 1 *Semnopithecus*) lie within 70.0–79.9. Thus there is a great overlapping of the human series; but, if we exclude the anomalous orang, the two lowest cercopithecoid ratios are barely exceeded by the highest great-ape index. It may be concluded, therefore, that on the average the lateral condyle of the femur — as expressed by the area of its tibial articular surface — is practically as large as the medial one in man, somewhat smaller than the medial condyle in the cercopithecoid monkeys, and less than two-thirds the size of the medial condyle in the great anthropoid apes. This general conclusion appears justifiable even in view of the small sizes of the series involved. Our single specimens of siamang and gibbon suggest that the Hylobatidae resemble the monkeys rather than the great apes.

Certain other generic differences are also suggested, but the question of their reality must await study of much larger series. These possible differences, however, do not appear to be necessarily associated with habitat or posture. It is true that among our Cercopithecidae the relatively largest lateral condyles are found in the largely terrestrial macaques (*Macaca*) and patas monkeys (*Erythrocebus*), yet the also terrestrial baboons (*Papio*) have lateral condyles that are comparatively as small as or smaller than those of the largely arboreal langur (*Semnopithecus*) and proboscis monkey (*Nasalis*). Similarly, among the great anthropoid apes, the almost wholly terrestrial gorilla has the relatively smallest lateral condyle, whereas the lateral condyle of the wholly arboreal orang-utan — even excluding the aberrant specimen — equals that of the chimpanzee.

It is thus obvious that the size ratio between the condyles of the femur is no index of posture or mode of locomotion. If *Plesianthropus* possessed a relatively large lateral condyle



(or relatively small medial condyle, as Le Gros Clark put it), and this remains to be determined, it no more indicates an erect, bipedal posture than a pronograde, quadrupedal posture.

#### DISCUSSION

In conclusion, the following may be said of the *Plesianthropus* femur:

1. In the great robustness of its shaft, it distinctly resembles the cercopithecoid monkeys rather than man, and is quite unlike the anthropoid apes.

2. In its rather high angle of shaft obliquity, it resembles both man and gorilla, less closely resembles the other great apes, and is far removed from the average cercopithecoid.

3. In the contour of its patellar surface, it is quite like man and the cercopithecoids, and is wholly unlike the great apes.

4. As to the relative sizes of its condyles, some ambiguity exists. If the inference of Broom is correct, that the medial condyle is relatively better developed than in man, the fossil is herein more nearly anthropoid than hominid or cercopithecoid. If, however, the statement of Le Gros Clark is accepted, that the medial condyle is relatively less strongly developed than in the anthropoid apes, *Plesianthropus* resembles both man and the cercopithecoids and is dissimilar to the great apes. It may be noted, for what it is worth, that Broom was speaking particularly of the anterior portions of the condyles, whereas Le Gros Clark, although stressing the posterior portions, was presumably referring to the entire condylar areas when he concluded that "In the *Plesianthropus* femur, the proportionate sizes of the two condyles are quite similar to those of *Homo*." Tentatively accepting Le Gros Clark's estimate of condylar sizes, then an alignment of the fossil with man and the Cercopithecidae rather than with the great apes is suggested.

5. Regarding the intercondyloid notch, we are unable to speak with any great degree of conviction, for reasons noted above. In its great depth or height the notch of *Plesianthropus* is possibly unique but most closely approached by individual specimens of man, gorilla and orang-utan; it is certainly far

removed from the notches of the Cercopithecidae. In the formation of an antero-lateral secondary notch the fossil possibly lies closest to man; but here again it presumably finds its counterpart in individuals of other primate groups. In its general shape, the fossil notch appears unlike that of the average anthropoid ape and more like that of the average man and Old World monkey.

Leaving aside the notch, of which we cannot speak with any feeling of certainty, 4 characters remain for consideration. *Plesianthropus* closely resembles the average man in three of these characters (shaft obliquity angle; patellar surface; relative condyle sizes, presumably). It likewise resembles the average cercopithecoid monkey in three characters (shaft robustness; patellar surface; relative condyle sizes, presumably). On the other hand, it is unlike the great anthropoid apes in all of these points (although it does closely resemble the gorilla in its angle of shaft obliquity), being distinctly different with respect to shaft robustness, patellar surface and, presumably, relative condyle sizes. Hence, while the morphology of the Sterkfontein femur is definitely not great-ape, at the same time it is not peculiarly or exclusively hominid, for it resembles man and cercopithecoid monkey in about equal degree. Wherein it departs from the average hominid it approximates the average cercopithecoid (shaft robustness), and wherein it departs from the average cercopithecoid it approximates the average hominid (angle of shaft obliquity). Its characters *in toto*, therefore, no more betoken an erect, bipedal posture than they do a pronograde, quadrupedal posture.

Perhaps the most noteworthy results of our study of the lower end of the femur are, first, the demonstration of the much greater resemblance between human and cercopithecoid femora than between human and great-ape femora, and, second, the failure to discover any distinctive external character in the human femur that can be regarded as peculiar to the upright, bipedal posture. The usually large angle of shaft obliquity found in man is generally considered to be an adaptation to erect, bipedal posture (e.g. by Walmsley, '33), but

what of those men who have small angles, and what of the frequently large angle in the gorilla? Likewise, if a relatively large lateral condyle is to be correlated with lateral load bearing and truly erect posture in man, what is its meaning in the Old World monkeys? Perhaps they likewise bear their weight laterally. If so, however, then this character may be an adaptation to erect posture in man but not necessarily an inevitable index of such posture. Similar comments might well be made, if one were so inclined, regarding relative condyle-shaft robustness and morphology of the patellar surface. Obviously, many of our easy assumptions respecting correlation of form and function stand in need of re-examination. We are accustomed to thinking of the femur of man as an outstanding example of an adaptation peculiarly associated with his erect, bipedal posture. Assuming that the characters under discussion are necessarily adaptive ones — and this remains to be proven — it might as logically be concluded that man was able to achieve the erect, bipedal posture partly by reason of having inherited a type of femur that was cercopithecoid at its lower end. In other words, we may well be dealing here with an instance of constitutional preadaptation inherited from pronograde, quadrupedal ancestors.

#### SUMMARY

The lower end of a left femur, found at Sterkfontein, South Africa, and attributed to the fossil Australopithecine primate, *Plesianthropus transvaalensis*, has been briefly described by Broom ('46) and studied in more detail by Le Gros Clark ('47). Using the latter's description and illustrations, we have compared this fossil femur with those of existing catarrhine primates:

1. In its great shaft width (relative to bicondylar width) it is cercopithecoid rather than hominid or anthropoid.
2. In its large angle of shaft obliquity, it especially resembles both man and gorilla, rather than the other big anthropoids and the cercopithecids.

3. In its patellar-surface contour it is quite similar to both man and the cercopithecids, and wholly unlike the great apes.

4. Regarding the relative sizes of its condylar tibial or "weight-bearing" areas, ambiguity exists. Broom inferred that the medial condyle is comparatively larger than is usual in man, whereas Le Gros Clark stated that the condylar-size ratio is definitely hominid. Neither author, however, seems to have measured the areas of the condylar articular surfaces. On an average, we find that the tibial articular surface of the lateral condyle is nearly as large as that of the medial condyle in man and somewhat smaller in the cercopithecids, but less than two-thirds its size in the great apes. The overlapping between the great apes on the one hand and man and monkeys on the other hand is moderate. Tentatively accepting Le Gros Clark's estimate of relative condylar sizes, *Plesianthropus* thus resembles both man and cercopithecids rather than the great apes.

5. The intercondyloid notch of *Plesianthropus* is very high and forms a secondary notch at its antero-lateral border. Lacking a cast, it is very difficult to make comparisons with extant primates. Possibly the fossil notch is unique in its great height. A secondary notch occurs in both man and other primates. In general shape the fossil notch most nearly resembles those of man and the cercopithecids.

Leaving aside the uncertain notch, the *Plesianthropus* femur is definitely not great-ape in morphology. It resembles the femur of man and those of cercopithecoid monkeys in about equal degree.

Both Broom and Le Gros Clark have claimed that the characters of the *Plesianthropus* femur are peculiarly hominid and definitely indicate that the animal was capable of assuming the erect, bipedal posture. In view of its equally close resemblance to the femur of man and those of cercopithecoid monkeys, however, it cannot be said to be more hominid than cercopithecoid, nor to be more indicative of an erect, bipedal posture than of a pronograde, quadrupedal posture.



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## ADDENDUM

Since this paper went to press, one of us (H.M.K., Jr.) has had the opportunity of studying a series of femora of Hylobatidae. The results of this study, including the few specimens listed in our tables, follow:

1. Robustness index: 4 *Symphalangus*, 43.1 (39.2-45.2); 19 *Hylobates*, 42.4 (36.7-46.0).
2. Obliquity angle of lower shaft: 3 *Symphalangus*, 3.9° (0.9°-5.4°); 17 *Hylobates*, 5.4° (1.5°-11.1°).
3. Form of patellar surface: 5 *Symphalangus*, medial "lip" higher in 4, lateral "lip" higher in 1; 17 *Hylobates*, medial "lip" higher in 11, lateral "lip" higher in 5, "lips" equal in 1.
4. Relative height of intercondyloid notch: 6 *Symphalangus*, 52.4 (47.7-58.1); 18 *Hylobates*, 50.2 (44.5-55.2).
5. Relative size of tibial surface of lateral condyle: 4 *Symphalangus*, 86.0 (77.5-90.0); 16 *Hylobates*, 76.5 (56.3-100.0).

These results do not differ fundamentally from those given in our tables. It may now be stated, however, that although the femur of *Plesianthropus* is unlike those of the great apes, it presumably (following Le Gros Clark) bears a closer resemblance to the femora of the Hylobatidae in the relative size of the lateral condyle; in relative notch height, however, it is nearer to those of the great apes. Furthermore, while the great apes and hylobatids are not identical, neither bears as close a total resemblance to *Plesianthropus* as either the cercopithecids or man.



FOSSIL ORANGS OF ASIA.—The orang-utan has now been recognized as a typical element to the *Stegodon-Ailuropoda* fauna from the lower or middle Pleistocene caves of southern China, where it is represented by a large race, *Pongo pygmaeus weidenreichi* nov. subsp. The Malayan affinities of the *Stegodon-Ailuropoda* fauna have been stressed by various authors . . . There can be no doubt that these animals, constituting the Sino-Malayan fauna of von Koenigswald, migrated to Java via the Sunda Shelf, past Sumatra or Borneo . . .

The fauna of the Mogok caves in Upper Burma, though still imperfectly known, is apparently closely related to the cave fauna of southern China, and may be considered as an element in this faunal complex . . . The orang-utan is so far lacking in Burma, but this species has been found to the south of China in the Tam-Hang and Tam-P'a-Loi caves in Indo-China, supposed to be early Pleistocene in age. . . .

It is a curious fact that truly Pleistocene or late Tertiary vertebrates have not been found as yet in Sumatra . . .

Recently Weidenreich ('45) has proclaimed *Gigantopithecus blacki* von Koenigswald, evidently a member of the *Stegodon-Ailuropoda* fauna of southern China, to be probably the ancestor of the lower Pleistocene *Pithecanthropus robustus* Weidenreich and of *Meganthropus palaeojavanicus* von Koenigswald from Java. The large size of the *Gigantopithecus* molars certainly is no objection against this view, as some of Weidenreich's critics . . . hold. The evidence of 3 isolated teeth, however, is too scanty. Not until the complete dentition of the giant Chinese hominid will be known, we might make out whether the latter is the ancestor of the fossil Javan hominids or only a representative of an extinct sidebranch.—D. A. Hooijer. Prehistoric teeth of man and of the orang-utan from central Sumatra, with notes on the fossil orang-utan from Java and southern China. Zoologische Mededeelingen, Leiden, vol. 29, 1948, pp. 175-301.

## A NOTE ON GROWTH, SOMATOTYPE AND TEMPERAMENT

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Ever since *The Varieties of Human Physique* was published, some critics have objected to its interpretation of somatotypes in terms of the three basic germ layers. In this book, Sheldon, Stevens and Tucker ('40) describe endomorphy as an enlargement of the endodermal viscera. Mesomorphy represents an expansion of the mesodermal structures, while ectomorphy is a predominance of ectodermal body surface over volume and a relatively large ectodermal nervous system. Although this viewpoint seems adequate for purposes of nomenclature, it stills leaves much to be desired. The rest of this paper will present a different view of the somatotype components, based on later processes of growth, together with a brief discussion of developmental features in the theory of temperament as presented by Sheldon and Stevens ('42).

One criticism of the original theory of endomorphy is that, in most endomorphs, there is as much dominance of mesodermal tissues as of the endoderm. Dissections show that endomorphs have large digestive viscera, but actually only the lining of these organs is endodermal. The remainder is derived from the splanchnic mesoderm (Patten, '46). Furthermore, the fat padding in these endomorphic carcasses arises almost entirely in mesodermal derivatives.

If endomorphy were a harmonious predominance of the endoderm, the endomorph should show enlargement of the pharynx, eustachian tube and middle ear, posterior lobe of the pituitary, the thyroid, parathyroid and thymus glands, lungs

and urinary bladder, the entire urethra in the female, and the prostatic portion of the male urethra. Some of these features may well be found in endomorphs, but others probably are not. For example, a high vital capacity, roughly indicative of large lungs, is not confined to endomorphs, and some endomorphs have moderate vital capacities.

Mesomorphy can be called a predominance of the somatic mesoderm, but this view is not completely adequate. For example, there is probably some concordance of mesomorphy with tough, thick fingernails, which are ectodermal. Evidence from the Grant Study (Hooton, '45) suggests that mesomorphy is associated with superior vision — chiefly a function of ectodermal structures. Some of the massiveness of the mesomorphic frame probably results from a relatively great effectiveness of the ectodermal anterior lobe of the pituitary during growth.

The ectomorphic physique shows a predominance of brain mass and skin area over body volume, yet these tissues are not absolutely larger than in other body types. On the other hand, the mesomorph has the heaviest bones and muscles, and the endomorph has the heaviest gut of the three polar somatotypes. These facts suggest that ectomorphy is more of a reduction of the inner germ layers than an overgrowth of the ectoderm. The original theory of somatotypes, like the earlier embryologists, made too much of the autonomy of the germ layers.

In maturation, the interaction of tissues from more than one germ layer usually takes precedence over the hypertrophy of any single layer at the expense of the others. This statement is based on the findings of experimental embryologists on "organizer" tissues and their role in development (Stockard, '31). The work of Spemann and his successors on transplanted embryonic structures indicates that the axial complex of endoderm and mesoderm calls forth the initial organization of the whole body. Various tissues act as organizers in sequence, and their effects on their surroundings are certainly not confined to one germ layer.



There is evidence that likeness of structure in any two organs makes for harmony of size — presumably as a result of specific endocrine action. The two organs need not stem from homologous embryonic origins. For example, the post-cranial skeleton is histologically rather uniform, despite the distinct origins of its axial and appendicular bones, yet a massive or gracile skeleton is generally so in all its parts. The head, however, seems to be structurally distinct from the trunk, and disharmonies between the two are very common. Genetic or racial factors may contribute to such instability, since the head is generally less subject to environmental alteration than the rest of the body (Hooton, '46). Bone and muscle, moreover, are quite unlike, despite their intimate attachments, so that a massive skeleton often supports a weak musculature, as in emaciated mesomorphs.

Dysplasias may well be partly congenital as well as purely inherited. Stockard ('31) has shown that an embryonic tissue is most liable to insult or stunting at its moment of origin, when its metabolic rate and the tempo of its cell divisions are at a peak. He produced many sorts of monstrous embryos of the minnow *Fundulus* by depriving them of oxygen or poisoning them at appropriate growth stages. Some local dysplasias in man are probably the effects of such early stunting. The areas of greatest metabolism change as new organs arise, and mishaps such as an inadequate engorgement of the uterine wall while implantation is taking place might lead to dysplasia anywhere in the body.

Dysplasias are localized disturbances of harmonious growth; whereas the somatotype components describe trends which involve the whole organism. In elucidating the origin of these components, embryonic development is less useful than later stages of maturation. Ontogeny is a time-honored means of clarifying biological perplexities, and it can serve the student of constitution today as it has the evolutionist since the days of Darwin and Haeckel.

Every normal organism has a certain balance in the relative size of its parts at each stage of its life, and these re-

lationships may change drastically or slightly as it grows. If the changes are profound, the organism shows adultiform specialization. If the changes are slight, it retains infantile features throughout life. Some human races are structurally more infantile than others, and the same is true of the various somatotypes. In his course at Harvard in constitutional anthropology, Hooton describes the changes in structural harmony during the human life cycle. He considers the infant as essentially an endomorph. The child becomes increasingly ectomorphic until the prepuberal growth changes, and later increases in mesomorphy. In my opinion, androgyny is equally amenable to a developmental approach, and the pattern of its changes during growth is also reasonably clear. Modern data on child development make it possible to discuss the average patterns of appearance and subsidence of both androgyny and the somatotype components.

Adults differ widely in their development of skin and fat, viscera, nervous system, muscle and skeleton. Each somatotype probably has its own characteristic proportions of these tissues and organs, yet Wilmer ('40) has found that in a series of fetuses at the age of 6 lunar months, the ratios of the weights of these structures to the total body weight were remarkably consistent. During later growth, such ratios become more and more variable. I interpret these findings as evidence that human physiques at this early stage are relatively similar, and that the somatotypes become progressively differentiated in later maturation.

Scammon ('30) has plotted the annual increments of weight in various organs throughout maturation, and Stuart and Sobel ('46) have described changes in the subcutaneous fat in the calf of the leg during childhood. A deposition of this fat appears in the 7th intrauterine month and continues to thicken after birth. The fetus achieves an early predominance of the viscera, so that the infant has a relatively large liver and digestive tract. These and other infantile attributes persist in the endomorph, and it seems reasonable to consider endomorphy as the "infantile" component of physique.

The subcutaneous fat attains a considerable depth by the postnatal age of nine months. This stage seems to be the peak of the endomorphic process of growth.

The enormous postnatal expansion of the nervous system seems to be the herald of the juvenile or ectomorphic trend of growth. Three noteworthy phenomena occur during this phase: the enlargement of the nervous system to nearly its adult size, a rather slow growth of the heart, kidneys and many other body structures, and almost no growth of the gonads. After the age of nine months, an absolute attrition of the subcutaneous fat sets in. This loss is slower after the age of three years. From  $5\frac{1}{2}$  to 11 years of age, the fat layer maintains a rather constant thinness. The neck size increases slowly during the juvenile trend, and the trunk and limbs become attenuated. This trend apparently reaches a peak at about the age of 9 years, and its consummation is very reminiscent of adult ectomorphy. Much of what Scammon ('30) calls growth of the "neural" type occurs in the ectomorphic stage.

From about the age of 8, the mesomorphic growth trend sets in. The heart, kidneys and adrenals go into more rapid growth, followed shortly by the total body weight. The neck size shows a particularly rapid spurt as a result of muscular expansion. These changes lead to the flowering of mesomorphy and occur at a maximal rate toward the end of the adolescent growth spurt. The gonads, too, begin to enlarge slightly at the age of 8, but this increase is not pronounced until about 12. In the early stages of the mesomorphic trend, girls are about a year ahead of boys. Later the disparity averages about two years. The mesomorphic trend is usually stronger in men than in women, and continues to a slight extent in the young adult.

The complex growth changes of pubescence involve both androgyny and sexual differentiation. The gynecic changes in boys include a temporary enlargement of the nipples and sometimes a deposition of fat in the breasts (Stuart, '46). Boys grow more slowly than their female age-mates, and often look slightly

rounded and feminine. A brief average rise and fall of the male leg fat at about the age of 11 may be part of this trend (Stuart and Sobel, '46). By about the age of 14, the boy's statural spurt and muscular development have usually obliterated the earlier gynec trend.

Girls go into a growth spurt at the time of the boys' gynec shift. They have broader shoulders and hips and are taller than boys at about the age of 13 (Stuart, '46). Just before their pelvic alterations begin at around 12, they often seem to verge briefly toward the andric body form. By 13, they have usually undergone enough pelvic changes and put on enough fat so that this andric trend is obscured.

These temporary shifts toward androgyny take place early in the development of the secondary sex characteristics. Although the urinary output of estrogens and 17-ketosteroids is not a precise measure of the interaction of sex hormones in the body, such interaction is probably involved in the directions of growth of pubescence (Stuart, '46). Clinical evidence indicates that psychic linkages accompany this endocrine activity, and it is also true that the pubescent shift toward androgyny occurs at a time when some children in our culture show a maximal homosexual orientation (Seward, '46). The early andric growth spurt in the female and the later andric spurt in the male both result from comparable androgen secretions. Presumably the gynec male retains or exaggerates the body build of pubescence which the andric male loses; and conversely, the andric female retains characteristics of her pubescent growth stage.

The trends relative to the somatotype components and androgyny overlap, and each begins before the peak of the preceding trend. The extent of these phases is probably influenced by the action of genes at specific stages of growth. There is already some evidence on the operation of the growth phases in the polar somatotypes.

The adult endomorph has presumably stressed his infantile stage of growth. Stuart and Sobel ('46) have shown that he usually retains thick subcutaneous fat in childhood, al-



though it undergoes considerable reduction during the juvenile stage. Insofar as the mesomorphic and andric changes are slight, a delay in sexual maturation may result, and small genitalia develop in the male.

The extreme mesomorph has exaggerated, and perhaps prolonged, the mesomorphic and andric stages of maturing. Such features may account for his "overmaturity of appearance."

The ectomorph seems to stress and prolong the juvenile stage, and the shifts toward mesomorphy, androgyny and sexual differentiation at pubescence are slight. As a result, extreme ectomorphs of both sexes look rather similar in outline, just as children do. Charts of subcutaneous fat changes during growth indicate that the 10th percentile line of thin deposition does not change in early adolescence in boys (Stuart and Sobel, '46). It would appear that thin boys do not acquire a thicker panniculus at this stage. The 10th percentile line in girls climbs somewhat, presumably because fat on the calf of the leg is a female secondary sex characteristic (Bayer, '40). If the ectomorph's growth pattern is a true prolongation of the juvenile trend, it is not surprising that his sexual maturation is late (Sheldon, Stevens and Tucker, '40).

Evidence on whether environment can alter the ultimate effect of each growth stage, and hence the adult somatotype, is still meager. Perhaps the modern trend in the more civilized nations toward tallness and away from endomorphy arises from some such change, although it is sometimes explained as a "survival of the unfittest" (Hooton, '46). Growth and weight charts from some European growth studies show a much less clear onset of the mesomorphic weight increase than in recent American series (Stuart, '46). Modern children are apparently maturing faster than their ancestors. Growth curves of early investigations can be fitted to modern series by setting the points of inflection some 6 months earlier in time (Scammon, '30). Environment has probably decreased the age of menarche in modern American girls as compared to their mothers (Gould and Gould, '32).

Such precocity of development might hasten the infant's shift into the juvenile growth stage and hence accomplish the modern loss of endomorphy.

Further research in constitution should determine whether anything like the childhood stages of physique, particularly in endomorphy, can recur in the adult. Occasional individuals seem to add endomorphy with advancing age. It would be interesting to learn whether this change is associated with visceral growth, and whether it is mediated by living habits, heredity, or both.

Just as the embryo shows signs of its species at an early age, the child's build may foretell his later somatotype. In the early years of growth, certain organs are larger or more mature than others, and two patterns or gradients describe these differences (Scammon, '30). Maturity increases both from the trunk toward the head (cephalocaudal gradient) and from the limbs toward the body axis (proximodistal gradient). Perhaps these gradients vary among individuals. A pronounced lag in the development of the trunk might result in an adult with a full sized head and a puny body, that is, an ectomorph. A slight proximodistal gradient might account for the relatively large limbs of the ectomorph. A retarded development of the limbs might result on the bulky trunk and puny extremities of an endomorph. In testing these hypotheses, the steepness of the gradients could be measured both structurally and in terms of motor activity, especially in infancy.

Stuart and Sobel ('46) have found that a person usually maintains his approximate percentile rank in superficial fat thickness from birth to early adolescence at least. Bone and chronological age can now be used to predict adult stature and some other attributes of the mature physique (Bayley, '43). Other features such as skeletal mass, muscularity or visceral size might have predictive usefulness as well. It is likely that the somatotyping of children down to fairly young ages by these and inspectional criteria will soon be possible. It is still too early, however, to discuss how any growth stage

or gradient comes to be emphasized or prolonged, or how man might alter the adult physiques of his children through changes in their environment.

The perennial problem of standardizing the rating scales for adult female somatotyping could be attacked by work on photographs of children of both sexes from a longitudinal growth study. One could begin by somatotyping the boys in late adolescence on male adult criteria. The next step would be to study the same individuals at earlier ages until ratings corresponding to those of the adult could be made at the age of 8, based on objective and verbalized inspectional criteria. Next, these criteria would be applied to girls at a physiologically comparable age: i.e., 7, and the somatotypes determined. These ratings would then be arbitrarily applied to the same individuals in late adolescence. The final stage would be to draw up and verbalize the adult inspectional ratings from the late adolescent photographs. Such a procedure would result in somatotypes for both sexes which would correspond quite closely in early growth, and perhaps even in some features of heredity.

Although cultural and psychological influences on temperament will not be elaborated here, an association between changes in physique and temperament seems to exist, at least in our society. As endomorphy is the infantile trend in physique, so viscerotonia is the infantile temperament. Dependence on people, a love of sleep and digestion, and pleasure in elimination are traits common to infancy and viscerotonia.

A major attribute of cerebrotonia is a vivid and almost undisciplined imagination. Children in our culture generally reach a peak of imaginal powers during the ectomorphic growth stage. The cerebrotonic has a wistfulness for the dreams of childhood but a repugnance toward the reality of childhood, presumably because of its traumatic effect on him. His restraints and inhibitions may well result from a permanent arrest of some features of his personality during the juvenile growth stage.

Somatotonia is less easily disposed of in a developmental scheme, since a love of exercise is most evident in children soon after they learn to walk. There is an air of the permanent adolescent about the somatotonic, however, and youth is his favorite period of life (Sheldon and Stevens, '42).

Further studies of the human constitution should determine whether physical and psychological maturity are associated in specific individuals. The ultimate usefulness of this or any other scheme of total maturation should be to define the limits within which heredity operates, so that it can be reasonably dealt with or dismissed in particular researches on man.

#### SUMMARY

Sheldon's view of somatotype as a simple predominance or balance of one or more of the embryonic germ layers is not entirely adequate. Six months' fetuses show great consistency in the relative contributions of various tissues to the total body weight, and hence, the somatotypes at this age are probably not well differentiated. Endomorphy in the adult is best described as a retention of a growth phase which reaches a peak at the postnatal age of 9 months. It may also be the outcome of a steep proximodistal growth gradient which exaggerates central rather than peripheral growth. Ectomorphy is a retention of the growth phase of childhood which reaches a peak at the age of 9 years. It may result from a steep cephalocaudal gradient which produces a full sized head on a puny body. Mesomorphy is an exaggeration of an adolescent growth stage. A transient shift toward androgyny often occurs as the secondary sex characteristics begin to develop in either sex. Perhaps both environment and heredity affect the duration and retention of effects of these various stages. A plan is offered whereby somatotype criteria for women could be established through growth studies on both sexes.

Viscerotonia is presumably the infantile temperament, cerebrotonia the temperament of later childhood, and somatotonia is a prominent trend in adolescence in Western culture: It is



not unlikely that these tendencies are considerably alterable through cultural influences.

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INCIDENCE OF JEWISH INTERMARRIAGE.—Generalizations concerning an ever-increasing rate of Jewish intermarriage in America are not substantiated by comparative analysis of the facts available here and abroad. Jewish intermarriage does not necessarily adhere to a

pattern of increasing incidence. It varies in time and place according to the fluctuations of social conditions.

There is endogamous strength in numbers. However, unlike some other numerically small religious groups . . . , such as the Greek Orthodox and Greek Catholics, the Jewish rate of intermarriage has been low. Two explanations to account for this discrepancy are the following:

1. . . . A higher economic status provides the Jews with horizontal mobility to the larger neighboring Jewish communities, permitting them to overcome the handicap of small numbers.

2. The longer, more varied history of migration by the Jews, and their centuries of existence as a minority in proximity to gentile majorities enabled them to develop attitudes and techniques of intermarriage resistance long before their arrival in America.—Milton L. Barron. The incidence of Jewish intermarriage in Europe and America. *Am. Soc. Rev.*, vol. 11, no. 1, 1946, pp. 6-13.

CHINESE JEWS.—I confess to a thrill of excitement upon meeting with the several families of Chinese Jews whom Bishop White had brought together. Of the seventeen families, or clans, which originally came to K'ai-fêng Fu, there were present representatives of five clans—Chao, Ai, Li, Shih and Chang. . . . As they sat there, dressed in their Chinese costumes, several of the older women with bound feet, I realized the truth of what I had read so often—the power of the Chinese to assimilate completely any race of people. Swarthy in colour, and with characteristic features when they first came to China [between 960 and 1126 AD], all is now changed, for the most part, to the colour and general facial appearance of the yellow race. I scanned these faces closely for that look and those features which we term Jewish, and all but those of the Chao and the Widow Shih were definitely and distinctly Chinese. The Widow Shih could pass without trouble for a Baghdad or Indian Jewess, except for her bound feet. Her face was oval, with eyes wide and open, and her nose was typically Jewish.—David A. Brown. Through the eyes of an American Jew. (Quoted by William Charles White in *Chinese Jews*, 3 vol., The University of Toronto Press, 1942).

# A COMPARISON OF RURAL AND URBAN BIRTH SEX RATIOS FOR THE TOTAL, THE "WHITE" AND THE "COLORED" U. S. POPULATIONS

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Dusing (1884) was one of the first to call attention to a possible difference between rural and urban birth sex ratios. He concluded on the basis of a few European data that the proportion of males is higher for rural live births than for those of urban centers. His conclusions have been widely quoted and often assumed to hold true for the rural and urban populations of all countries.

In 1906 Vigor and Yule calculated the correlation between the proportion of male live births and the total number of live births in various rural and urban areas of England and Wales. They summarized their results as follows: "The districts which had the largest proportion of male births, were for the most part the provincial towns or semi-urban districts, the more purely rural districts and purely urban districts of large towns exhibiting a distinctly smaller proportion." Lewis and Lewis ('06) calculated directly the live birth sex ratios of cities, towns, and rural areas of Scotland for the years 1872 to 1901, inclusive. They obtained the highest proportion of males, 51.74 per cent, for the insular rural districts, and the lowest, 51.20 per cent, for the principal cities. Russell ('36) examined the live birth sex ratios for London and surrounding urban country and rural districts for the years 1911 to 1920, inclusive. He found that the strictly rural area had for this time interval a slightly higher percentage of male births than did the city of London. The percentage of males of the

two other types of districts he found to be intermediate. Ciocco ('38) published, as part of a longer paper, a brief report on the sex ratio for live births of rural and urban areas in the United States. His data were taken from the U. S. census records and covered the two 5-year intervals, 1925-29 and 1930-34. He summarizes his conclusions in the following short sentence. "In sum, in this country the effect of urbanism on the sex ratio is entirely negligible."

What we have done in the present study has been to examine the problem, not only with respect to the live births of U. S. rural and urban populations, but also with respect to stillbirths. Furthermore we have examined the question relative to the two racial subdivisions of the U. S. population, designated by the Bureau of the Census as "white" and "colored." The data which we have selected are for the 15 year interval from 1922 to 1936 inclusive. Our reason for choosing this particular time interval was primarily to conform to the interval selected previously for a number of other populational analyses (Strandskov, '45; Strandskov and Siemens, '46; and Strandskov and Ondina, '47).

The procedure which we have followed has been: (1) to collect the yearly rural and urban live birth and stillbirth data from the U. S. census records for the years 1922 to 1936, inclusive, (stillbirths for 1936 excepted, because the census records do not separate the stillbirth data for this particular year into rural and urban categories), (2) to calculate the percentage of males for each year for the different types of birth, (3) to obtain a mean of each of the distributions of 15 or 14 yearly percentages of males among the births, and (4) to compare statistically the obtained means for significance of difference. Our categories of urban and rural populations represent, respectively: (1) cities of 10,000 or over, and (2) smaller towns combined with the more strictly rural areas. We appreciate that this subdivision may not conform exactly with everyone's understanding of what are urban and rural populations, but the division seems to us to be fairly satisfactory for our purposes. We also know that laws relative to the recording of



stillbirths differ for the different states, but this difference between states should be relatively unimportant for our analysis since the total rural and urban data are represented by about equal numbers from each of the states. Furthermore, we understand that, while the "white" U. S. population probably represents only members of the Caucasoid stock, the "colored" includes not only members of the Negroid stock, but

TABLE 1

*The number of live births and stillbirths, the number of males, and the mean of 15 or 14 yearly percentages of males in the U. S. urban and rural populations.<sup>1</sup> (Urban implies cities of 10,000 or over; rural implies the combination of smaller towns with strictly rural districts)*

	NO. OF BIRTHS FEMALES AND MALES	NO. OF MALES	MEAN PERCENTAGE OF MALES
<b>I. TOTAL POPULATION</b>			
A. Live births			
1. Urban	14,803,554	7,605,074	51.373
2. Rural	15,909,993	8,169,338	51.352
B. Stillbirths			
1. Urban	540,197	306,970	56.810
2. Rural	534,753	308,143	57.663
<b>II. "WHITE" POPULATION</b>			
A. Live births			
1. Urban	13,614,523	7,000,942	51.422
2. Rural	13,724,140	7,057,034	51.422
B. Stillbirths			
1. Urban	453,192	257,660	56.817
2. Rural	398,028	228,771	57.473
<b>III. "COLORED" POPULATION</b>			
A. Live births			
1. Urban	1,189,031	604,132	50.790
2. Rural	2,185,853	1,112,304	50.927
B. Stillbirths			
1. Urban	87,005	49,310	56.641
2. Rural	136,725	79,372	58.119

<sup>1</sup> Live birth data are for the years 1922 to 1936 inclusive; stillbirth data are only for 1922 to 1935, inclusive.

also members of the Mongoloid stock and even some Caucasoids. However, since more than 95% of the representation of the "colored" population is of Negroid stock any data pertaining to it may be considered fairly representative of the U. S. Negro population.

We shall not present the yearly data for each of the different populations, but shall list only the totals for the 15 or 14 year periods together with the calculated means of the 15 or 14 yearly percentages of males.

TABLE 2

*Table of t values obtained from comparisons of the means of the distributions of 15 or 14 yearly percentages of males among the births of urban and rural U.S. populations*

POPULATIONS COMPARED <sup>1</sup>	t VALUE
WC, LB urban (51.373) vs WC, LB rural (51.352)	.816
WC, SB urban (56.810) vs CS, SB rural (57.633)	4.918
W, LB urban (51.422) vs W, LB rural (51.422)	.000
W, SB urban (56.817) vs W, SB rural (57.473)	3.276
C, LB urban (50.790) vs C, LB rural (50.927)	1.746
C, SB urban (56.641) vs C, SB rural (58.119)	6.481
W, LB urban (51.422) vs C, LB urban (50.790)	10.710
W, LB rural (51.422) vs C, LB rural (50.927)	8.692
W, SB urban (56.817) vs C, SB urban (56.641)	0.698
W, SB rural (57.473) vs C, SB rural (58.119)	3.828

<sup>1</sup> WC = total population; W = "white" only; C = "colored" only; LB = live births only; SB = stillbirths only; urban = cities of 10,000 or over; rural = smaller towns combined with the more strictly rural areas.

Table 1 gives the live birth and stillbirth data for rural and urban populations for the total population, and also the corresponding data for the "white" and the "colored" populations considered separately.

In order to comment in precise terms regarding the observed differences between percentages of males among the births of the different populations which are considered, we have applied the standard formula for a test of the significance of the difference between two means.

$$t = \frac{\Delta}{\sqrt{\frac{(X_1 - \bar{X}_1)^2 + (\bar{X}_2 - X_2)^2}{N_1 + N_2 - 2} \cdot \frac{N_1 + N_2}{N_1 N_2}}}$$

For the comparisons which have been made a  $t$  value of two or more has a probability of .05 or less and may, therefore, be considered indicative of a difference not due to chance alone. Table 2 gives the  $t$  values obtained.

For a discussion of the causes of some of the observed differences in percentage of males for the various categories of

TABLE 3

*The percentages of all birth which represent stillbirths in the urban and rural populations of the total, the "white" and the "colored"*  
*U. S. populations from 1922 to 1935 inclusive*

POPULATION	NO. ALL BIRTHS REPORTED	NO. STILLBIRTHS	STILLBIRTH PERCENTAGE
Total			
Urban	14,330,794	540,197	3.77
Rural	15,312,913	534,753	3.49
"White"			
Urban	13,142,809	453,192	3.45
Rural	13,165,171	398,028	3.02
"Colored"			
Urban	1,187,985	87,005	7.32
Rural	2,147,722	136,725	6.37

birth it seemed desirable to have available information regarding the percentages of all births which are stillbirths within each of the three populations which we have considered. These percentages are given in table 3. The data represent only the 14 year interval from 1922 to 1935, inclusive, because, as we have indicated previously, stillbirth data for 1936 are not separated in the census records into rural and urban categories.

#### DISCUSSION

Table 1 shows that the percentage of males for live births, considering all racial groups collectively, is 51.37 for the urban population and 51.35 for the rural. The difference is not sta-

tistically significant. Hence we may conclude that no difference exists between the sex ratios of U. S. rural and urban live births for the time interval, 1922 to 1936. This conclusion is in agreement with that drawn by Ciocco ('38) as it should be, since he examined the live birth data for two 5 year intervals within the 15 year period which we have considered.

When the "white" and the "colored" U. S. populations are considered separately it is found that the same conclusion holds true for each one of them.

When the sex ratios of the stillbirths of rural and urban populations for 1922 to 1935 are compared it is found that the percentage of males for rural stillbirths (considering "white" and "colored" populations in combination) is 57.66, whereas it is only 56.81 for urban stillbirths. As table 2 shows the differences gives a  $t$  value of 4.9 and consequently appears to be due to factors other than those of chance alone. When we examine the corresponding data for the "white" and the "colored" populations, considered separately, we note the same relationship. In other words, with respect to the total U. S. population and also each of its two racial subdivisions the percentage of males for stillbirths is significantly higher for rural populations than for those of urban centers for the 14 year period under consideration.

What the factors were which were responsible for this higher percentage of males for rural stillbirths is not easy to determine, but perhaps some plausible explanations may be suggested. The usual explanation for an observed high percentage of males for the stillbirths of a given population is that it is the result of the high proportion of stillbirths in the population in question. This explanation is based on the fact that some causes of stillbirth are known to act differentially against the male fetus. However, if we examine table 3 we note that for each of the three populations which we have considered, the percentage of males is higher for rural populations, but that the proportion of stillbirths relative to all births is lower. Hence the usual explanation for a high percentage of males for stillbirths does not appear to be applicable to



these observed results, at least not without some modification or reservation.

What other explanations for the observed results seem probable, or what modification of the usual one will make it more applicable? Bisaccia ('47) and others have shown that the percentage of males relative to stillbirths varies with the uterine age of the stillborn fetuses. Bisaccia obtained the following percentages of males for the 7th, 8th, 9th and 10th months: 53.52, 55.20, 57.32 and 57.84, respectively. These percentages are based on large numbers and are significantly different. From a consideration of these percentages it will be apparent that if a higher proportion of 7th month fetuses were included among the stillbirths reported for one population than for those reported for another, the percentage of stillbirths relative to all births would be higher for the first population, but the percentage of males for the reported stillbirths of the first population would be lower. These are exactly the relationships which we have observed for U.S. urban and rural populations. It is true that we have very little direct evidence that a higher proportion of 6th or 7th month stillborn fetuses were reported by urban than by rural populations, during the interval under consideration, but we are inclined to believe that this may have been true. If the above explanation is the correct one for our observed results an actual difference between U. S. rural and urban populations, relative to percentage of stillbirth and percentage of males among stillbirth, may have existed during the time interval under consideration.

Other possible explanations for our observed results relate to possible differences between rural and urban populations in size of family, percentage of illegitimate births and in genetic factors. None of these explanations, however, appear to be applicable.

So far we have compared only sex ratios within populations which presumably are close to being genetically the same in both rural and urban components. If we examine table 1 we note that percentages of males for "white" rural and "white"

urban live births are identical (51.42) and that the corresponding percentages for the "colored" population are 50.79 and 50.92, respectively. Table 2 shows that both the rural and the urban live birth sex ratios of the "white" are significantly higher than the corresponding ratios for the "colored" population. These higher percentages of males for "white" live births probably are due in part to higher percentages of stillbirths for the "colored" population. However, they probably also reflect the action of genetic factors. As we have pointed out in a previous paper (Strandskov, '45) the white population probably possesses genetic factors which tend to produce a higher primary sex ratio in favor of males than do genetic factors within the "colored" population. How these factors operate is not known, but probable modes of action could readily be suggested.

With respect to percentage of males among stillbirths some interesting racial differences are also observed. Table 2 shows that the percentage of males for urban stillbirths of the "colored" population is slightly lower than the corresponding percentages of the "white" population. However since "colored" populations probably have a lower conception sex ratio than do "whites," the observed stillbirth sex ratio for the "colored" urban population may actually represent a relatively higher urban stillbirth sex ratio for the "colored" population than for the "white." With respect to the sex ratios of rural stillbirths our data show that the "colored" populations have significantly higher percentages of males than do corresponding "white" ones. These relatively if not actually higher percentages of males for "colored" rural or urban stillbirths probably are due primarily to the higher percentage of stillbirths noted for the "colored" populations. Table 3 shows that the percentage of stillbirths is nearly twice as high for "colored" populations as it is for corresponding "white" ones.

The factors which were responsible for the higher percentage of stillbirth for the "colored" populations probably were environmental rather than genetic.

## SUMMARY

1. The percentages of males for live births and stillbirths within the total, the "white" and the "colored" rural and urban U. S. populations, for the 15 year interval from 1922 to 1936, are calculated and compared.

2. It is found that the live birth sex ratios for U. S. rural and urban populations for the period under consideration are not significantly different. This is true not only for the total populations, but also for the "white" and the "colored" populations considered separately.

3. The percentage of males for rural stillbirths for the period under consideration is found to be significantly higher than the corresponding percentage for urban stillbirths. This holds true not only for the total population but also for the "white" and the "colored" populations considered separately.

4. "White" and "colored" rural populations are shown to be represented by lower percentages of stillbirth than are corresponding urban populations. Hence the higher percentages of males for rural stillbirths than for urban stillbirths do not appear to be due to higher percentages of stillbirth. It is suggested that they are due in part at least to the reporting of fewer 6th or 7th month stillbirths in rural areas.

5. "White" rural and urban populations are found to have a higher percentage of males for live births than do corresponding "colored" populations. These differences are attributed in part to differences in percentage of stillbirth, but primarily to racial differences in genetic factors which determine primary sex ratios.

6. "Colored" rural and urban populations are found to have relatively, if not actually, higher percentages of males for stillbirths than do corresponding "white" populations. These differences are attributed primarily to higher percentages of stillbirths for "colored" populations.

7. The higher percentages of stillbirth for the "colored" populations are assumed to be due primarily to environmental factors rather than to genetic ones.

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NEW DATA ON GENE LINKAGE IN MAN.—We have recently been investigating the linkage relationships of the genes for sickle cells and for the various blood groups and types. To date 33 families have been tested. Although we found no evidence against random assortment between the gene for sickle cells and the genes for the A-B blood groups and the Rh types, we did find evidence that the gene for sickle cells is linked with those for the M-N blood types.

... Out of our 33 families there were 5 in which 1 parent had sickle cells and was type MN... As rapidly as possible we are adding to the collection of families.—Laurence H. Snyder, Henry Russell and Eugenia B. Graham. Linkage between the genes for sickle cells and the M-N blood types. *Science*, vol. 106, no. 2754, Oct. 10, 1947, pp. 347-348.



## BODY MEASUREMENTS IN THE LIGHT OF FAMILIAL INFLUENCES <sup>1</sup>

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According to the record thereof, at the Viking Fund Conference on Precision in Anthropometry, held December 13, 1947, Dr. Fejos at one juncture suggested that the problem of anthropometry is (1) what to measure, (2) why it is to be measured, and (3) how to measure it. This conference was principally concerned, like previous committees and groups, with techniques of measuring, and it does appear to be true that we know little about *what* should be measured and why — whether one measurement is more significant or sensitive or more profitable to employ, than another.

Possibly this the reason why the remark is occasionally made at meetings or in writing that anthropometry seems to be a sterile field. It is made usually by speakers who are discussing the genetic approach to problems of human variation: such a frame of mind inclines students to look more for discrete and isolable (usually non-measurable) properties of an organism, leading them to wonder what may be the actual real quantities, if any, other than simple relative size, which are being observed by anthropometric techniques. It is a point of view worth considering.

This paper is an attempt to find, from experimental data, distinctions of a particular sort among certain measurements commonly taken in racial or growth studies. The hypothesis

<sup>1</sup> This paper was originally presented at the 17th annual meeting of the American Association of Physical Anthropologists, April 4, 1948, at Washington, D. C.

<sup>2</sup> The study was supported by the Research Committee of the Graduate School, from special funds voted by the Wisconsin State Legislature.

is this: members of the same family (in this case, pairs of brothers) will differ less in their measurements than will randomly chosen individuals of the same population, and this effect — of a smaller-than-average difference — will be more marked in some measurements than in others; in other words, some diameters will be more responsive to this familial factor than others, and this will serve as one criterion for making distinctions between different measurements in use. This is not an attempt to measure the force of genetic influences; no separation is being made of the effects of common heredity and of common family environment. That is not the point: it is simply that the undifferentiated factor of the family is being used as a probe to find cleavages between different diameters measuring different aspects of the body.

The material consists of approximately 96 pairings of brothers (an actual maximum total of 182 individuals) drawn from the student body of the University of Wisconsin, and described by the writer in a previous number of this journal (Howells, '48).<sup>3</sup> These yield, in each measurement, a mean absolute difference (all differences taken positively). For comparison with these mean brother differences, two sets of means were obtained to show the degree of difference which might be expected between individuals paired at random from the same population. One set, the "expected" differences, was derived mathematically, by using the standard deviation of this whole population (see footnote, table 1) and the same  $N$  as the observed pairings, in each measurement. The other set was obtained empirically, by drawing 100 actual pairs of individuals at random from the total pool of brothers (the "random pairs" in the tables).

Table 1 compares these three sets of mean differences. It is to be noted that for the "expected" and the "random pairs"

<sup>3</sup> The measurements were made in 1941 and 1942 by Dr. Earle L. Reynolds, then my research assistant and now physical anthropologist of the Fels Institute, Yellow Springs, Ohio. Much of statistical work for this paper was done by Mr. Neil C. Tappen and Dr. Richard L. Hornseth, and I am also obliged to the latter for valuable advice on statistical procedures.

the figures are fairly similar throughout; and it may be said, without citing the figures, that in no measurement is the difference between the means of these two columns of a significant size (under a 5% level of probability). Furthermore, in all cases the mean difference between actual brothers is less than that "expected" and less than that obtained by actual ex-

TABLE 1

*Mean absolute pair differences, in millimeters*

	BROTHERS	EXPECTED <sup>1</sup>	RANDOM PAIRS <sup>2</sup>
Stature	46.21 <sup>3</sup> (92)	68.54 <sup>3</sup> (92)	67.90 (100)
Sitting height	28.82 (94)	34.27 (94)	37.07 (100)
Biacromial	16.71 (96)	20.17 (96)	18.57 (100)
Bi-iliac	13.38 (96)	17.14 (96)	16.10 (100)
Upper arm length	14.29 (94)	19.31 (94)	17.08 (100)
Length of radius	9.52 (96)	14.20 (96)	13.51 (100)
Length of tibia	15.17 (93)	24.44 (93)	25.82 (100)
Head circumference	12.67 (95)	16.57 (95)	15.59 (100)
Head length	5.92 (95)	7.24 (95)	7.50 (100)
Head breadth	4.44 (96)	6.07 (96)	5.98 (100)
Head height	4.75 (96)	7.05 (96)	6.32 (100)
Minimum frontal	3.84 (96)	5.25 (96)	5.28 (100)
Bizygomatic	4.36 (96)	5.28 (96)	5.76 (100)
Bigonial	5.18 (94)	6.18 (94)	5.60 (100)
Face height	5.03 (96)	8.09 (96)	7.51 (100)
Upper face height	4.22 (96)	6.05 (96)	5.77 (100)
Nose height	3.58 (96)	4.92 (96)	4.57 (100)
Nose breadth	2.33 (96)	2.71 (96)	2.75 (100)
Ear length	3.15 (96)	3.65 (96)	3.25 (100)
Ear breadth	2.14 (96)	2.46 (96)	2.71 (100)

<sup>1</sup> If it is assumed that, in any variable, the older and younger brothers are each normally distributed, with identical means and standard deviations, then differences between pairs of older and younger, drawn at random and treated without regard to sign, will also be normally distributed, with a mean equal to  $1.12837916\sigma$  and a standard deviation equal to  $.852502457\sigma$ . (The  $\sigma$  to be used here is derived from the separate  $\sigma$ 's of the older and younger

brothers series by the formula  $\sigma = \sqrt{\frac{\sigma_1^2 + \sigma_2^2}{N_1 + N_2}}$ , since the means are assumed to be identical;

this is not the same as the standard deviation for "all brothers" in table 3, Howells, '48.) This formula is obtained from Irwin ('25). I am much indebted to Dr. Richard L. Hornseth of the Department of Sociology and Anthropology for finding and modifying it for me.

<sup>2</sup> From the total group of brothers, 100 pairs were drawn at random and irrespective of brotherhood (by using Tippett's tables of random numbers), with the single limitation that the pairs differed in age by at least one year.

<sup>3</sup> The following comparable figures were computed from Pearson ('25): for 341 pairs of brothers, mean observed difference in stature 51.66 mm, mean difference expected (by formula) 75.03 mm; for 482 pairs of sisters, mean observed difference 51.23 mm, mean expected difference 75.52 mm.

periment. This is not the important thing, however; it is to be expected anyhow, from the hereditary factor alone. The important thing is that the proportionate decrease, under the familial influence, is much greater in some measurements than in others; i.e., brothers are much more similar in some diameters than others, relative to the expected, random difference. This, of course, is another form of the statement that fraternal correlation differs considerably in different measurements (see Howells, '48).

Table 2 makes this kind of comparison in clearer fashion. In the first column is given the Critical Ratio of the difference between the first two columns of table 1; i.e., the divergence is found between the mean difference of brothers and the corresponding expected random mean difference, and is divided by the standard error of that divergence (this Critical Ratio resembles the commonly used x.p.e.). The measurements are listed in order of magnitude of the Critical Ratio. It is to be seen that this is statistically significant at a 5% level of probability<sup>4</sup> in all measurements but nose breadth and the ear diameters. It is highest in a group of longitudinal measurements, led by length of face and of lower leg; in fact, all longitudinal measurements are at or near the head of the list, with the somewhat startling exception of sitting height. These are followed by breadths of the head and of the body, with head breadth and minimum frontal diameter being especially high, and nose breadth and bigonial particularly low.

In the second column of table 2, the differences of brothers are compared with the differences of pairs actually drawn at random (the "random pairs") but the comparison is of the variability of the pair differences, not of the mean quantities:  $f$ , a ratio of variances, measures the significance of differences in variability (see footnote, table 2). Here, a high  $f$  signifies that the inter-brother differences have a distinctly

<sup>4</sup> Having a Critical Ratio of 1.96 or over. While this might be taken as a level of significance in individual random comparisons, it is obvious that none of the differences in this list can be considered as arising from chance, because of the existence of a general factor affecting all of them.



diminished range of variation as compared to differences obtained from chance pairings, and confirms independently, in a somewhat different way, the indications given by the previous comparison. The order of listing is of course that given by the Critical Ratio, but the rank as regards  $f$

TABLE 2  
*Measures of significance of differences in*

	MEAN DIFFERENCES (BROTHERS VS. EXPECTED) Critical Ratio <sup>1</sup>		VARIANCES (BROTHERS VS. RANDOM PAIRS) Values of $f$ <sup>2</sup>		COEFFICIENT <sup>3</sup> OF CORRELATION	
	<i>Sig. at</i>		<i>f</i>	<i>Rank</i>	<i>Sig. at</i>	<i>r</i>
Face height	4.94	1%	2.42	2	1%	.59
Length of tibia	4.82	1%	2.89	1	1%	.58
Head height	4.26	1%	1.55	13	5%	.49
Length of radius	4.25	1%	2.10	3	1%	.52
Stature	4.14	1%	2.08	4	1%	.47
Upper face height	3.89	1%	1.92	5	1%	.51
Nose height	3.53	1%	1.52	14	5%	.51
Head breadth	3.47	1%	1.66	10	1%	.48
Minimum frontal	3.39	1%	1.74	6	1%	.47
Upper arm length	3.35	1%	1.44	16	5%	.43
Head circumference	3.02	1%	1.58	12	5%	.42
Bi-iliac	2.85	1%	1.52	15	5%	.36
Head length	2.36	5%	1.70	9	1%	.38
Bizygomatic	2.24	5%	1.42	17	5%	.27
Biacromial	2.22	5%	1.33	18		.45
Bigonial	2.08	5%	1.23	20		.30
Sitting height	2.04	5%	1.72	7	1%	.35
Nose breadth	1.81		1.64	11	1%	.25
Ear length	1.79		1.32	19		.28
Ear breadth	1.68		1.71	8	1%	.22

<sup>1</sup> Critical Ratio =  $\frac{\bar{X}-\bar{Y} - 1.1284 \sigma}{.8525 \sigma / \sqrt{N}}$ . The numerator is the difference between the observed

mean difference between brothers and the mean difference between pairs drawn at random from this population; the denominator is the standard error of this difference. See the footnote to table 1. A Critical Ratio of 2.58 indicates a 1% level of probability, of 1.96 a 5% level of probability.

<sup>2</sup>  $f = \sigma_1^2 / \sigma_2^2$ , or the ratio of the variances of the populations compared. More fully,

$f = \frac{\sum x_1^2}{N_1} - M_1 / \frac{\sum x_2^2}{N_2} - M_2$ , where  $x$  represents the absolute individual differences and  $M$  represents the net, not the absolute, mean difference. For samples approximating the size of those involved here, an  $f$  of 1.61 indicates a 1% level of probability, and an  $f$  of 1.40 a 5% level.

<sup>3</sup> From Howells, '48.

is shown, and the level of probability for significance is also given. Again, the longitudinal measurements stand high, are most affected by the familial factor, and the breadth measurements in general are low. Head height falls, however, and both sitting height and ear breadth go up. Table 2 also includes the coefficient of correlation between these brothers, which is necessarily strongly related to the mean differences.

TABLE 3

	CRITICAL RATIO	MEAN PAIR DIFFERENCES, PERCENTAGE EXCESS OF			
		"Expected" over "brothers"		"Random pairs" over "brothers"	
		%	Rank	%	Rank
Face height	4.94	61	1	49	2
Length of tibia	4.82	61	2	70	1
Head height	4.26	48	4	33	8
Length of radius	4.25	49	3	42	4
Stature	4.14	48	5	47	3
Upper face height	3.89	43	6	37	6
Nose height	3.53	37	7	28	11
Head breadth	3.47	37	8	35	7
Minimum frontal	3.39	37	9	38	5
Upper arm length	3.35	35	10	20	15
Head circumference	3.02	31	11	23	14
Bi-iliac	2.85	28	12	20	16
Head length	2.36	22	13	27	12
Bizygomatic	2.24	21	14	32	9
Biacromial	2.22	21	15	11	18
Bigonial	2.08	19	16	8	19
Sitting height	2.04	19	17	29	10
Nose breadth	1.81	16	18	18	17
Ear length	1.79	16	19	3	20
Ear breadth	1.68	15	20	27	13

Table 3 deals once more with the mean differences themselves as shown in table 1. The first column repeats the Critical Ratio from table 2, giving the same order of measurements; this of course is a measure of *significance* of difference. The second column, however, gives the percentage by which the "expected" difference (table 1, column 2) exceeds the "brothers" difference (table 1, column 1), and there ap-

pears also the ranking of the measurements by this criterion. The third column makes the same comparison of the "random pairs" differences (table 1, column 3) and the "brothers" differences. There is the expected close relationship between the order of the proportionate differences and the significance of those differences, when the comparison involves the "brothers" and the "expected" differences. The same comparison between "brothers" and "random pairs," however, also gives a strongly similar order, the general relations being those already noted. In actual percentage, the average difference between brothers is little below what chance might provide, in such features as ear length and bigonial breadth.

#### SUMMARY

Workers in anthropometry and craniometry have been apt to assume that one measurement of the body was as good as another for purposes of discrimination among racial or other groups; such an assumption is implicit, for example, in the old "coefficient of racial likeness." In the present paper this assumption is tested by examining whether pairs of brothers differ more in some body measurements than in others, taking as the basis of comparison the average difference between randomly selected members of the same population. Those traits in which brothers are relatively most alike are those in which the average brother difference falls furthest below the average difference of random individuals. Both the absolute deviations and the Critical Ratio are used to compare the measurements.

In this respect, the measurements which are most responsive to this factor of brotherhood are longitudinal measurements, above all those of the bones of the lower leg and arm and the heights of the facial skeleton. Total stature is one of these, but it is suggested that this is largely traceable to the contribution of the legs, since sitting height gives the lowest proportionate difference among longitudinal measurements. However, head height (included in sitting height) ranks well up. Longitudinal, antero-posterior, and transverse measure-

ments of the head are perhaps less distinguished than those of the body, on the whole, with head breadth, head circumference, head height and minimum frontal breadth appearing in the upper or middle part of the list. Bigonial breadth, however, is far down. Bi-iliac and biacromial breadths are low, with nose breadth, ear length and ear breadth bringing up the rear; these are the traits which brotherhood affects the least.

There thus appear to be clear differences in how critical various measurements are when tested by this one criterion. (Presumably the common genetic background of the brothers is the principal element in this familial influence.) It should be remembered, however, that this is only one possible criterion by which to test the different measurements or traits, and has here been used simply as a demonstration of one kind of distinction among them. There is much to be learned yet about the individual susceptibilities and the relative worth of our ordinary measurements.

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# DISTRIBUTION OF THE BLOOD GROUPS, M-N AND RH TYPES AMONG ESKIMOS OF THE KUSKOKWIM BASIN IN WESTERN ALASKA <sup>1</sup>

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The distribution of the various blood groups (O, A, B, AB), M and N factors, and the Rh types among the American Indians has been a matter of considerable interest to ethnologists and serologists. Because of the high incidence of group O among most tribes of Amerinds as reported by several investigators, (Matson and Schrader, '33, table page 156, '41; Matson and Piper, '47) and of the extraordinarily high distribution of group A among the Blackfeet and related tribes as reported by Matson ('33, '38, '46), and Matson and collaborators ('33, '36), it has been suggested that the American Indians were at one time either a pure group O or group A people, depending upon the particular tribe in question.

Similarly, the finding of significant differences in the distribution of the M and N factors among American Indians as compared to whites and other races, (Landsteiner and Levine, '29; Levine, Matson and Schrader, '35, '36; Wiener et al., '45; Matson and Piper, '47) has been a noteworthy contribution to ethnologists. In Amerinds, the M factor is unusually high (more than 90%) whereas the N factor is low.

The recently discovered inheritable factors, Rh and Hr, present in human blood have been shown to vary in their racial

<sup>1</sup> This work was aided by a grant from the Research Fund, University of Utah, and by the Miles Laboratories, Inc., Elkhart, Indiana.

distribution. Although only a few racial studies have been made on the Rh factor, the incidence among Amerinds has been found to be extremely high (practically 100% as compared to 85% among whites, (Landsteiner, Wiener and Matson, '42; Wiener et al., '45; Matson and Piper, '47), and agrees with the incidence of this factor among other primitive peoples; Chinese (Levine and Wong, '43; Wiener et al., '44), Australian aborigines and Indonesians and other South Sea peoples (Simmons et al., '44, '45), Japanese (Waller and Levine, '44), and Eastern Arctic Eskimos (Jordan, '46).

This unusual distribution of the blood groups and other hereditary factors in the blood of American Indians has led to considerable speculation in regard to their distribution in the blood of Eskimos. Only a few studies have been made of the distribution of these factors among this people, (Heinbecker and Pauli, '28; Bay-Schmith, '27, '30; Freuchen, '32; Fabricius-Hansen, '39; Sewall, '39). Recently (1944) Victor E. Levine examined the distribution of the blood groups and Rh factor among Eskimos living at Nome, Alaska, and in 1938 at Point Barrow.<sup>2</sup> More recently (1946) Jordan has investigated the distribution of the blood groups and Rh factor among the Eskimos of the Eastern Arctic. The findings of all these workers are shown as comparative data in appropriate tables in this article.

#### EXPERIMENTAL

In the summer of 1947 it became our privilege to make a systematic survey of the distribution of the blood groups, the M and N factors, and Rh factors among the Eskimos in Western Alaska in the Kuskokwim Basin at Bethel. Bethel is a trading post for Eskimo villages up and down the Kuskokwim and for Eskimos in Tundra villages and for those residing on Nunivak Island located about 50 miles from the mouth of the Kuskokwim River in the Bering Sea.

<sup>2</sup> Personal communications. (The reader is reminded that these data supplied earlier by Dr. Levine and used here by Dr. Matson in his tables 1 and 2 may differ slightly from those to be published soon by Dr. Levine — Ed.)

At Bethel, the Alaska Native Service maintains a hospital for the Eskimos. An exceptional opportunity was afforded one of us (G.A.M.) to obtain blood specimens from Eskimos who came to this hospital for treatment. Specimens were obtained from putatively full-blooded Eskimos from villages up and down the Kuskokwim, from Bethel and also from Nunivak Island. Furthermore, the villages of Napakiak and Napaskiak were visited and specimens were taken from putatively full-blooded Eskimos in these villages. These villages are among the oldest on the Kuskokwim. We were informed that the most primitive of all the Eskimos reside in this area, including Nunivak Island (cf., Hrdlička, '33).

#### MATERIALS AND METHODS

Duplicate blood specimens were obtained by puncturing with a Hagedorn needle the finger cleansed with 70% ethanol and allowing several drops of blood to fall into a sterile, chemically clean, dry, serological tube, about 10 ml in diameter. Immediately after collection, the numbered tubes containing the clotted blood were stoppered and put into a cool sample container and transferred to the refrigerator. On the same day that the blood samples were taken, each specimen was tested for the blood group, M and N factors and Rh<sub>0</sub> (D) type.<sup>3</sup> The duplicate specimens were sent via air express to the Blood Grouping Laboratory, Department of Bacteriology, University of Utah, Salt Lake City, and were placed, immediately upon arrival, in a refrigerator and tested on the day of arrival. For the most part, the blood samples arrived in excellent condition. In the Blood Grouping Laboratory these were tested for blood group, M and N factors and the various specificities of Rh; (Rh' [C], Rh<sub>0</sub> [D], and Rh'' [E] ).

Potent anti-A and anti-B sera used in the tests were of high titer and avidity. They had been produced in group B and A volunteers respectively who had received intravenous inoculations of group A and B substance of Witebsky.

<sup>3</sup> The Fisher-Race terminology is given in parenthesis after the Wiener terminology to avoid confusion (cf., Castle et al., '48).

The anti-M and N typing sera were obtained from two sources: from the Certified Blood Donor Service in Jamaica, New York, and from stock supply prepared in our own laboratory. M and N typing sera from both sources were specific and had high titer and avidity.

The anti-Rh<sub>0</sub> (anti-D) typing serum was obtained from sensitized women who had given birth to erythroblastotic babies. This serum was absorbed and prepared in our Blood Grouping Laboratory. The anti-Rh' (anti-C) and anti-Rh'' (anti-E), testing serums were obtained from Dr. A. S. Wiener, 64 Rutland Road, Brooklyn, New York. All anti-Rh typing serums were of high titer and avidity.

The tests were done on approximately 2% suspension of cells which were made by shaking up the clots in physiological saline. The suspended cells were washed once and resuspended in saline solution to approximately 2% suspension. The blood group and M and N tests were done by placing in the depression of a Kline Slide a drop of 2% saline suspension of erythrocytes being tested and a drop of the appropriate testing serum. The cells and sera were mixed and the slide placed on a Boerner-Kline Rotator, covered with a petri dish to prevent undue evaporation, and rotated at a slow speed for 15 minutes. The tests were observed macroscopically and checked for fine clumping under the microscope. Rh tests were done in small 70 mm test tubes. For each test a drop of properly diluted anti-serum of each specificity Rh' (C), Rh<sub>0</sub> (D), and Rh'' (E), was placed in a separate tube. To each tube was then added one drop of 2% saline suspension of the erythrocytes being tested. The tests were incubated in a 37° water bath for one hour. They were then removed, numbered and centrifuged at a slow speed (about 500 r.p.m.) for one minute. Examination for agglutination was done by rotating each tube slowly at an angle to remove the packed cells from the bottom of the tube. Tubes were then examined macroscopically for agglutination with the aid of a concave mirror, observing the reflection in the mirror and also microscopically under the split 16 mm objective with a 10 × ocular.



## RESULTS AND DISCUSSION

Three hundred and forty-one specimens of blood from putatively full-blooded Eskimos were examined for the distribution of the blood groups (O, A, B, AB) among them. The results of the distribution of the blood groups are shown in table 1.

For comparison is shown in table 1 the findings of other workers among the Eskimos, and also the blood group distribution among whites.

The data on the blood group of Alaska whites was furnished by Mr. Ralph B. Williams, Director of Laboratories, Alaska Department of Health, Juneau. During World War II a program was worked out through the Division of Public Health Laboratories for typing the blood of all civilians in Alaska. The data on Alaska whites is partly the result of this service.

It will be observed from the table that the difference between the blood group (O, A, B, AB) distribution among Eskimos of Western Alaska and Alaska whites is not great. The Eskimos are slightly lower in group O (Eskimos 36.95%, whites 43.83%), but they are slightly higher in group A (Eskimos 44.87%, whites 41.69%) and AB (Eskimos 6.45%, whites 3.53%), whereas group B is practically the same for both peoples (Eskimos 11.73%, whites 10.95%).

Of the 153 group A and 22 group AB blood specimens tested, only 80 group A and 10 group AB specimens were tested for the sub-groups of A due to the small amount of suitable typing serum on hand at the time the tests were done at Bethel. All of these blood specimens tested, however, belonged to group  $A_1$  and  $A_1B$ , and none to  $A_2$  or  $A_2B$ . This agrees with the observations of Victor E. Levine who found  $A_2$  to be absent among 108 group A Eskimos tested at Nome. It is also in agreement with previous findings among Blackfeet Indians, (Matsen, Levine and Schrader, '36), and among native Hawaiians (Nigg, '30). As with the Blackfeet Indians there is also a high incidence of group A among Hawaiians. Practically 100% of group A is found also among Filipinos (Simmons and Graydon, '45), Papuans (Graydon and Simmons, '45), Fijians (Simmons et al., '45).

TABLE 1

*Distribution of the blood groups among putatively full-blooded Eskimos at Bethel, Alaska. Other data for comparison*

PEOPLE	INVESTIGATOR	NO. EXAM- INED	BLOOD GROUP FREQUENCIES						GENE FREQUENCIES			SUM OF GENE FRE- QUENCIES p + q + r
			O		A		B		p	q	r	
			no.	%	no.	%	no.	%				
Alaskan Eskimos (Bethel)	Present study	341	126	36.95	153	44.87	40	11.73	.299	.095	.607	1.001
Alaskan Whites	Present study	2,293	1005	43.83	956	41.69	251	10.95	.2594	.0755	.6616	.9965
Baffin Island Eskimos	Heinbrecker and Pauli, '28	166		55.40		43.40		0.60				
Pure-blood Labrador and Baffin Island Eskimos	Sewall, '39	146		55.50		43.80		0.00				
Mixed-blood Labrador and Baffin Island Eskimos	Sewall, '39	56		46.50		51.70		0.00		1.80		
Cape Farvel Eskimos	Bay-Schmith, '27	204		39.00		55.00		4.00		1.00		
Greenland Eskimos	Bay-Schmith, '30	484		41.10		53.80		3.50		1.40		
Greenland Eskimos	Freuchen, '32	340		43.50		47.10		7.30		2.10		
Greenland Eskimos	Fabricius- Hansen, '39	569		23.90		56.20		11.20		8.70		
Full-blooded Alaskan Eskimos (Nome)	Levine <sup>1</sup>	254		43.31		42.52		11.81		2.36		
Mixed-blood Alaskan Eskimos (Nome)	Levine <sup>1</sup>	68		44.12		42.65		11.76		1.47		
Full-blooded Alaskan Eskimos (Pt. Barrow)	Levine <sup>2</sup>	237		32.49		55.70		9.28		2.53		
Mixed-blood Alaskan Eskimos (Pt. Barrow)	Levine <sup>2</sup>	79		31.65		49.37		10.12		8.61		
Eastern Arctic Eskimos	Jordan, '46	369		43.00		53.00		2.40		1.60		

Similar absence of  $A_2$  has been observed among Chinese (Levine and Wong, '43; Wiener et al., '44), Indonesians (Simmons et al., '45) and among Japanese (Waller and Levine, '44; Graydon and Simmons, '45). On the other hand, in white individuals as many as one-fourth or one-fifth of A or AB individuals belong to  $A_2$  (Landsteiner and Levine, from table in Gates, '36) and the incidence of  $A_2$  in Negroes is the highest reported so far in any race (Landsteiner and Levine, from table 2 in Gates, '36, Wiener et al., '44). It seems that the incidence of  $A_2$  is low or absent in the more primitive and isolated races.

The data of Victor E. Levine recorded in the table are also instructive and show a close agreement between the distribution of groups O, A, B, and AB among Eskimos claimed to be pure and those known to be mixed, which agreement Levine concluded is an indication of marked admixture among the Eskimos. This similarity of the distribution of the blood groups among putatively full-blooded Eskimos, Eskimos known to be mixed, and whites, may be indicative of racial crossing, although this explanation does not necessarily follow from the blood group data alone. Their ancestors may not have been a pure group O or group A people when they first migrated to this hemisphere as appears to have been the case among the Blackfeet, Utes and other Amerinds. A number of putatively full-blooded Eskimos observed at Bethel did, however, show facial characteristics which betrayed white admixture. Furthermore, there is evidence of a strong Russian influence among these people so close to Russia across the Bering Sea. This Russian influence is particularly evident in their religious worship and probably dates back to their long contact with Russians before the territory was purchased from Russia by the United States. It is conceivable that considerable crossing occurred at this time with Russian traders.

The distribution of the M and N factors among the Eskimos at Bethel is shown in table 2.

From the table it will be observed that the blood specimens from 341 putatively full-blooded Eskimos at Bethel, Alaska, showed 47.80% to belong to group M, 41.64% to MN and

TABLE 2

*Distribution of the M and N factors among putatively full-blooded Eskimos at Bethel, Alaska. Other data for comparison*

PEOPLE	INVESTIGATOR	NO. EXAM- INED	FREQUENCY OF TYPES						FREQUENCY OF GENE		SUM OF GENE FRE- QUENCIES
			M		MN		N		$m = \sqrt{M}$	$n = \sqrt{N}$	
			no.	%	no.	%	no.	%			
Alaskan Eskimos (Bethel)	Present study	341	163	47.80	142	41.64	36	10.56	69.14	32.49	101.63
Pure-blood Labrador and Baffin Island Eskimos	Sewall, '39	146		32.30		15.80		52.00			
Mixed-blood Labrador and Baffin Island Eskimos	Sewall, '39	56		30.30		23.20		46.50			
Greenland Eskimos	Fabricius- Hansen, '39	569	475	83.48	89	15.64	5	0.88	91.30	9.40	100.7
Pure-blood Alaskan Eskimos (Nome)	Levine <sup>1</sup>	254		60.63		34.65		4.72			
Mixed-blood Alaskan Eskimos (Nome)	Levine <sup>1</sup>	68		51.47		42.65		5.88			
Ute Indians	Matson and Piper, '47	104	61	58.65	36	34.62	7	6.73	76.58	26.00	102.58
Blackfeet Indians	Matson et al., '36	95	52	54.74	38	40.00	5	5.26	74.00	23.00	97.00
Whites, Montana	Matson et al., '36	272	50	18.38	151	55.52	71	26.10	42.87	51.08	93.95

<sup>1</sup> Personal communication, '44.

TABLE 3

*Distribution of the Rh blood types among putatively full-blooded Eskimos at Bethel, Alaska. Other data for comparison*

PEOPLE	INVESTIGATOR	NO. EXAM- INED	Rh-		Rh <sub>1</sub>		Rh <sub>2</sub>		Rh <sub>1</sub> Rh <sub>2</sub>		Rh <sub>0</sub>		Rh'		Rh' Rh''	
			cde		CDe		cDe		CDE		cDe		cdE		CdE	
			no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%
Alaskan Eskimos (Bethel)	Present study	315	0	0.00	110	34.92	62	19.68	140	44.45	3	0.95	0	0.0	0	0.0
Ute	Matson and Piper, '47	104	0	0.00	35	33.66	30	28.84	39	37.50	0	0.00	0	0.0	0	0.0
Indians	Wiener et al., '45	98	0	0.00	47	38.00	9	9.20	41	41.80	1	1.00	0	0.0	0	0.0
Mexican Indians																



10.56% to N. Although the percentage distribution of N is low as compared to whites (26.10% in Montana) it is nevertheless somewhat higher than has been previously reported among other Eskimos or Indians, with the exception of the extraordinary findings of Sewall ('39) in Labrador and Baffin Island. This increase in the incidence of type N may be due to admixture with whites. Indeed, one would expect under such circumstances an increase in the percentage of type N and a decrease in the ratio  $\sqrt{M} : \sqrt{N}$ . This conclusion is borne out, not only by our findings, but also by the observations of most other workers among Eskimos, listed in table 2. Our findings among Eskimos are nevertheless in fair agreement with observations among Indians, (Landsteiner and Levine, '29; Levine, Matson and Schrader, '35; Matson et al., '36; Wiener et al., '45; Matson and Piper, '47).

It should be pointed out that although there may be a wide difference in the distribution of the blood groups, as for example among the Blackfeet who are predominantly group A (approximately 80%) as compared to the Utes who are group O (approximately 98%), that the N factor is consistently low. The reason for this may lie in the fact that whereas the blood groups are determined by a series of three allelic genes, the MN types are determined by a single pair of allelic genes. This would allow greater leeway for variation in the case of the blood groups.

It should be mentioned that whereas among Amerinds the frequency of the M factor is high and N is low, among Australian aborigines and the Ainu, the frequency is reversed, N being high and M low (Birdsell and Boyd, '40; Wilson et al., '44; Kubo, '36). The Bedouin and Hindus, on the other hand, like the Eskimos and Indians, are low in N (Boyd and Boyd, '38; Kayssi et al., '38; Greval et al., in Weiner, '43, table 75).

The distribution of the various Rh types among the Eskimos at Bethel, Alaska, is shown in table 3. Included also in table 3 for comparison, are data on the distribution of the sub-types of Rh among Ute Indians, Mexican Indians and whites.

Of the 315 blood specimens from Eskimos at Bethel, Alaska, none was found to be Rh negative (cde). The findings of Levine (personal communication) among 120 Eskimos at Nome, Alaska are in essential agreement with our observations in that only three individuals were found by him to be Rh negative. Levine accounts for these three on the basis of white admixture. Jordan ('46) found only one Rh negative individual among 369 Eastern Arctic Eskimos. Neither Levine nor Jordan made any observations as to the distribution of the sub-types of Rh among the Eskimos they studied. The absence of Rh negative individuals among the Eskimos at Bethel is in complete agreement with earlier findings among Amerinds (Landsteiner, Wiener and Matson, '42; Wiener et al., '45; Matson and Piper, '47; Sandoval et al., personal communication).

The marked difference in the distribution of the various sub-types of Rh among Eskimos and whites can be seen at once from table 3. On the other hand, the distribution resembles in some respects that found among the Ute and Mexican Indians. As among these Amerinds, so among the Eskimos, the only sub-types observed were Rh<sub>1</sub> (CDe), Rh<sub>2</sub> (cDE), Rh<sub>1</sub>Rh<sub>2</sub> (CDE), and Rh<sub>0</sub> (cDe). Of the 315 Eskimos examined, only three belonged to Rh<sub>0</sub> (cDe). The sub-types Rh' (Cde), Rh'' (cdE), Rh' Rh'' (CDe) were not found.

The significance of this ratio difference in the distribution of the sub-types of Rh is not yet clear. This appears to be the only study of the distribution of sub-types of Rh that has been made among Eskimos. Data of this sort may become more meaningful when further similar studies are made among primitive peoples. On the basis of data now available, however, it does seem clear that the absence of the Rh factor in certain peoples is a mutation that is almost peculiar to the more recent and advanced races, whereas in primitive races all individuals possess the Rh antigen.

#### SUMMARY AND CONCLUSIONS

A study has been made at Bethel, Alaska, of the distribution of the four Landsteiner blood groups (O, A, B, AB), the M and

N factors and Rh types among putatively full-blooded Eskimos residing in the Kuskokwim Basin and Nunivak Island. Of 341 blood specimens tested from these individuals, 126 or 36.95% were found to belong to group O, 153 or 44.87% to group A, 40 or 11.73% to group B, and 22 or 6.45% to group AB.

In agreement with previous observations among Blackfeet Indians, Native Hawaiians and other primitive and isolated races, the absence of  $A_2$  is notable among the Eskimos. Of 80 group A and 10 group AB specimens selected at random and tested for the sub-groups of A, all belonged to group  $A_1$  and  $A_1B$ . None were found to belong to  $A_2$  or  $A_2B$ .

For comparison data is included of tests done by Williams at the Alaska Department of Health at Juneau on blood specimens for 2293 Alaska whites. Of this number 43.83% belonged to group O, 41.69% to group A, 10.95% to group B, and 3.53% to group AB. These specimens were not tested for sub-groups of A.

The difference in the distribution of the blood groups between Eskimos in the Kuskokwim Basin of Alaska and Alaska whites is not great. This may indicate either racial crossing or a lack of homogeneous blood type among their first migratory ancestors to this hemisphere or both.

Of 341 blood specimens from putatively full-blooded Eskimos at Bethel tested for the M and N factors 47.80% belonged to type M, 41.64% to MN and 10.56% to N. This low incidence of type N is in fair agreement with other observations among Eskimos and Indians.

In agreement with the situation among primitive peoples generally as regards the incidence of Rh, there were no Rh negative (cde) bloods found among 315 specimens examined from putatively full-blooded Eskimos at Bethel. The sub-types of Rh found to be present among these 315 individuals were  $Rh_1$  (CDe), 34.92%,  $Rh_2$  (cDE) 19.68%,  $Rh_1 Rh_2$  (CDE) 44.45%,  $Rh_0$  (cDe) 0.95% (only three individuals). Sub-types  $Rh'$  (Cde),  $Rh''$  (cdE), and  $Rh' Rh''$  (CdE) were not found. Although the significance of the distribution of these sub-groups

of Rh is not clear, it is, nevertheless, in agreement with the distribution of these types among Mexican and Ute Indians.

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HUMAN GENETIC NOMENCLATURE.—No uniformity and no conformity to established rules exist relative to the assignment of names or symbols to the genes which have been shown to be directly responsible for specific human variations. This is unfortunate. The lack of uniformity and of conformity has led to confusion and to the impression on the part of many people that little or no exact human genetic knowledge is at hand, when actually much precise information is available.

An international committee on human genetic nomenclature should be established which would agree on names and symbols for human phenotypes and genes. Adherence to its decisions should then be encouraged or demanded. There is some hope that such a committee may be formed some time in the near future, but so far very little progress has been made towards its establishment. In the meantime the best that can be done is for individual geneticists to suggest and encourage the adoption of names and symbols which are descriptive, practical, and in conformity with certain rules which geneticists have found desirable to follow in their naming of genes which are responsible for genetic variation among lower forms.—Herluf H. Strandskov. Blood group nomenclature. *J. Hered.*, vol. 39, no. 4, April, 1948, pp. 108-112.

## BRIEF COMMUNICATIONS

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### A NEW MANDIBLE OF THE APE-MAN PLESIANTHROPUS TRANSVAALENSIS

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#### THREE FIGURES

When the book "The South African Fossil Ape-Men — The Australopithecinae" was published at the beginning of 1946, very little was known of the mandible — only a badly preserved middle region of an adult jaw, and a fragment of a symphysis of a juvenile.

About the middle of 1947 we discovered a nearly complete mandible of a large male with badly ground down teeth, and with the right ramus much crushed on to the left ramus. The left horizontal ramus is nearly perfect, and most of the left ascending ramus is preserved, but is still on the counterslab from which it could only be removed with difficulty and considerable risk. A short note on the mandible was published in "Nature" on August 2, 1947. The dentition is interesting from the fact that though the canine is fairly large it is ground down practically in line with the other teeth. A much fuller account of this jaw and its dentition is now in press.

A few months ago, on August 10, 1948, we discovered another nearly complete mandible of the male *Plesianthropus*. It was found in the same Sterkfontein cave as the other and only about two yards from it. This new mandible differs in many details from the other. Unfortunately the jaw had been badly broken before being fossilised, and the fragments have been considerably displaced. The teeth are rather less worn than in the other specimen. Most of the teeth are a little crushed, and the 3rd left molar crushed to an extreme degree.

The left horizontal ramus is nearly perfect from the front to about the plane of the back of the 2nd molar. The lower two-thirds of the

ascending ramus is also nearly complete but it has been displaced backwards and downwards, and on the inner side the portion of jaw which supports the 3rd molar has been much crushed and displaced downwards.

The anterior part of the right ramus had been detached from the symphysis, but practically no part has been lost. The part of the jaw behind the 1st molar had been quite detached and much displaced, but is also nearly complete. The condyle has also been preserved, but it had been detached and a little displaced. From the fragments it is possible to make an almost perfect restoration of the jaw.

The symphysis is fairly well preserved, and a very close approximation to a median section can be given. There is no trace of a simian

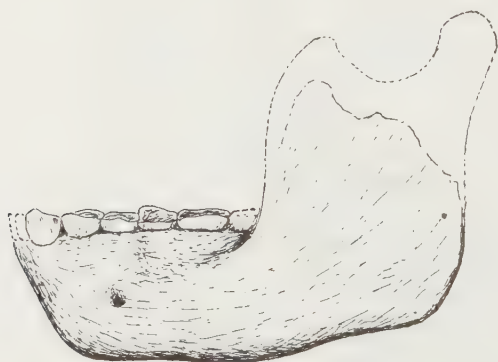


Fig. 1 Outer side of left lower jaw of male *Plesianthropus transvaalensis* (Broom). One-half natural size. The drawing is made from the two parts put together. The upper part of the ascending ramus is restored from the right side. The 3rd molar is restored in position.

shelf, but there is a distinct though not very deep genial fossa, or at most what might be called a rudiment of one. On the other hand, the imperfect symphysis of a very young male found in 1937 shows a very distinct pit. Broom gave a median section of this symphysis in 1946, and restored it with a simian shelf. This was probably an error. Most likely the lower part of the symphysis is rounded as in this new specimen.

In the child *Australopithecus africanus* there is clearly a genial pit. In the very fine jaw from the Makapan caves which Dart has just described (in the last volume of this journal) and referred to *Australopithecus prometheus* the symphysis is perfect, and the lower part rounded and without any trace of a pit or fossa or of a simian shelf. In the *Proconsul* jaw recently found by Leakey there is a very distinct



fossa but no simian shelf, and this appears to be the case in the small early anthropoids *Xcnopithecus* and *Limnopithecus*.

In man there is much variation in the symphyses of different types from the almost anthropoid type seen in *Eoanthropus* to the types seen in most modern men with no fossa and no simian shelf.

The front of the symphysis passes more downwards than backwards, and is not unlike that of *Sinanthropus*.

The restored side views of the jaw (figs. 1, 2) show the slope of the front of the symphysis. Though this is a restoration it is only a restoration in that the back half of the jaw which is displaced has been drawn in its original position, and the tip of the coronoid

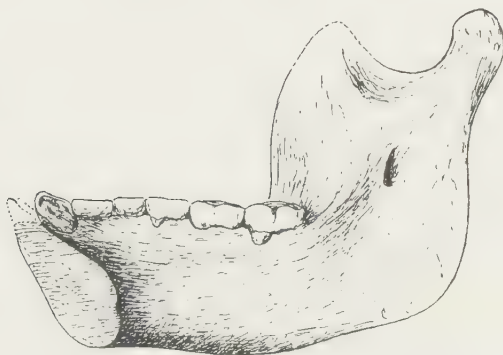


Fig. 2 Inner side of right lower jaw of *Plesianthropus transvaalensis* (Broom). One-half natural size. Partly restored. The part in front of the 2nd molar is drawn from the anterior part of the left jaw reversed. The part behind the 1st molar is drawn from the right jaw, but the detached condyle has been restored to the original position.

process which is lost from each side has been drawn from the continuation of the adjoining borders. The condyle is preserved on the right jaw and has been drawn in position before being detached.

The jaw is seen to have a considerable resemblance to that of man, and no very close resemblance to that of any of the anthropoids. The lower part of the ascending ramus is very similar to that of Heidelberg man, but the upper part differs markedly not only in having a better developed coronoid process, but in having the condyle more slender and extending much farther up.

We give restored drawings of the outer side (fig. 1) and inner side (fig. 2) of the jaw and an occlusal view (fig. 3) of the left dentition except the incisors which are broken and the 3rd molar which is extremely

crushed. The drawings can, we think, be relied on to about 3 or 4 mm but as there is this possible error we think it better not to give many measurements of the jaw, but merely restored drawings. Moreover the two sides are not quite symmetrical. The right ascending ramus at the level of the top of the 3rd molar has a width of 48.5 mm, but the left ascending ramus at the same level has a width of 54 mm.

The inner side of the right ascending ramus is satisfactorily preserved, and the general structure is as shown in the drawing. From almost immediately behind the 3rd molar a very marked bony ridge passes upwards and backwards. This is the torus triangularis. It is about as well marked as in the Heidelberg jaw.



Fig. 3 Dentition of mandible of male *Plesianthropus transvaalensis* (Broom). Natural size A. Dentition of left mandible, except for M 3 which is hopelessly crushed. B. Second and 3rd molars of right mandible. All these molars and premolars are slightly crushed, so that there is a possible error of  $\frac{1}{2}$  mm to 1 mm in some cases. The canine is uncrushed but considerably worn.

The inferior dental foramen is situated a little behind the middle of the ascending ramus. There is no distinct spine in front of it as there usually is in man. There is a slight mylohyoid groove passing downwards and forwards from its lower margin. The condyle differs considerably from that of typical *Homo*. In modern man there is much variation in the shape of the condyle. Even in *Sinanthropus* there is much difference in the condyle in males and females. In the male the condyle is a long narrow oval; in the female a shorter broader oval. In this *Plesianthropus* jaw the condyle is not unlike that of the female *Sinanthropus*.

On the outer side of the horizontal ramus below the 2nd premolar is a rather large mental foramen which is directed upwards and slightly forwards.

Most of the teeth are preserved, either completely or in part, but owing to crushing and wear absolutely perfect drawings cannot be made. In those given of the premolars and molars the outlines are nearly correct, and probable errors are not likely to be more than half a millimeter. The left canine is nearly perfectly preserved. It is a little worn and probably about the upper third is gone. It is interesting in showing the peculiar infolding of the back of the enamel in the canines of *Plesianthropus*, both upper and lower. The worn section of the tooth shows the enamel of the buccal surface curved so that the anterior half is almost at right angles to the posterior. On the lingual side there are two rather deep infoldings of the enamel, as shown in figure 3.

The premolars have their crowns worn down so that all that remains is a flattened surface of dentine surrounded by a ring of enamel.

The 1st molar has a little part of the top of the enamel remaining, and the 2nd molar a considerable part. But in neither of these teeth is the occlusal surface pattern satisfactorily seen. In the 3rd molar of the right side much of the occlusal enamel remains, but it is worn down nearly flat.

This mandible is essentially similar to the one previously found, and of which a description is being published elsewhere. Both show the essentially human character of the canines being ground down in line with the other teeth by meeting the upper canines.

As many anatomists are interested in the remains of these strange higher Primates which are being found in considerable abundance in South Africa, it seems but right that the world should have early information of the more important finds. The wealth of our deposits may be seen from the fact that in a year and a half we have discovered two fairly complete jaws of *Plesianthropus*, much of the mandible of a different type of ape-man which Dart has called *Australopithecus prometheus*, and a considerable part of the mandible of still another type of large ape-man which has been called *Paranthropus crassidens*.

It would be premature at this stage in our work to enter into any long discussion of the affinities of our South African higher Primates. Some of us regard them as closely related to man, though still with a relatively small brain, and with no close affinity with the anthropoid apes: others believe they are nearer to the anthropoids than to man. It is likely that in the near future the question will be conclusively settled.

## THE MEANING OF THE TERM *HOMO SAPIENS* AS IT IS USED BY FRENCH ANTHROPOLOGISTS

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American students of physical anthropology are often unwittingly led astray in their interpretation of French works on the subject, and especially on fossil man, by the manner in which the term *Homo sapiens* is used therein. The somatologists of non-Latin countries have come for the most part to use this term in an exclusively physical sense: they speak of *Homo sapiens*, as they speak of *Rhinoceros tichorinus* or *Rhinoceros merckii*, with the thought in mind of designating only an assemblage of physical characters, and without reference, conscious or unconscious, to the relative mental or spiritual status of the species in question. Thus many of them have come to classify the remains of Piltdown, Swanscombe, Galley Hill, etc., as *sapiens* (Coon, '39, pp. 20-21; Montagu, '45, pp. 122-123; Hooton, '46, p. 380) implying thereby merely that they believe these types to be directly ancestral to modern man, and so closely related to him physically as to warrant inclusion, in the zoological sense, in the same specific (if not subspecific) category. The failure of most somatologists of France and other Latin countries to place these early forms in the same classificatory position is sometimes more apparent than real (Teilhard de Chardin, '48, pp. 17-18, fig. 12), but in any event can be understood only when it is realized that, in more ways than one, they "don't speak our language."

Probably because Roman Catholicism, with its doctrine of the divine and independent creation of the human soul, is the overwhelmingly prevalent religious sect in Latin Europe, the physical anthropologists of that part of the world have long been inclined to lay special stress on the presence or absence of conscious abstract thought as the prime diagnostic character of *Homo sapiens*. For the most part they draw the rigid line of specific distinction between *Homo faber*, that catchall of presumably soulless though manually dextrous super-anthropoids or "préhominiens," and *Homo sapiens* who is Man (Boule, '46, pp. 554-555). And yet, as in the reference to Boule just cited, they employ at the same time a second standard of classification, the purely zoological standard of physical structural resemblance. Thus they tend to classify human and sub-human types according to an ambivalent system, using on the one hand aesthetic criteria such as the ability to



kindle and maintain fire, the custom of ceremonial burial, and the development of graphic art (Bergounioux and Glory, '44, pp. 9, 179 and 413), and on the other hand, and at the same time, the standard physical criteria such as cranial capacity, cephalic index, degree of erectness of posture, limb proportions, development of supraorbital and occipital tori, chin form, and other special skeletal characters — in short, those criteria employed generally in the English speaking world. Thus the somatologists of France and other Latin countries tend, more or less consciously, to establish their classifications of human and proto-human species on a psycho-philosophical basis, and then to proceed with the problems of subclassification on the basis of purely physical traits (Bergounioux and Glory, '44, p. 297). This approach can be very confusing to students from non-Latin countries, especially as the interpretation of the psycho-philosophical factors in question is more often implied than expressed. A singularly clear exposition of this ambivalent approach is to be found in the recent brochure by Teilhard de Chardin ('48, especially p. 11).

The weaknesses of the dual classificatory system are obvious. Where is the strict follower of this system to place *Homo neanderthalensis*, a form physically very different from modern man, and yet as evidently endowed with "human" intelligence (though probably to a lesser degree) as is witnessed by his practice of ceremonial burial of the dead? It is not easy to have your spiritual cake and eat it too.

And yet does not a very great difference of intellectual development, whether or not we accept it as divinely conferred, constitute a trait of major classificatory importance? Here the problem is, how to measure the character in question, how to determine at what point it had its beginning, how, in fine, to know if it ever had a precise beginning, or if it did not in fact appear imperceptibly out of nothingness and just grow, like a cloud in the sky. All this is for future generations, probably very far removed from us, to learn. What I want to accomplish in this note is simply to clarify for American students of physical anthropology a point of view seldom well understood by them, and which can lead easily to needless confusion in an already much confused subject.

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INHERITANCE OF DENTAL FEATURES.—On July 3, 1946, all 4 first permanent molar teeth were removed from each of a pair of monozygotic twins . . . The teeth were extracted because of hypocalcification and caries . . .

The degree of bilateral and intertwin similarity of all the anatomical features of these teeth is such that there can be no doubt of a genetic pattern for tooth morphology extending to even minute detail of root formation.

The possibility that these teeth are representative of genetic types prompted further search. Several types were found, some of which will be described. Within the different types some members were found to agree so closely with one another in anatomical form as to approximate the degree of similarity that commonly exists bilaterally in one mouth, or that found between the teeth of monozygotic twins. As segregation, upon the basis of morphology, proceeded, it became increasingly apparent that other characters co-existed within the types. The more apparent of these characters are: the color of the enamel and the degree of its translucency; the color and, in some cases, the translucency of the root; the surface texture of the root; the extent and color of the stains on the teeth; facets of wear on the teeth; the incidence or absence of dental caries in either the root or the crown, or in both; hypocalcification of the enamel: erosion, cracks and other defects in the enamel. Most, but not all, of these characters appear related to structure.

The small random sample of material that has been available does not admit of valid statistical analysis in the field of population genetics, but it illustrates micro-evolutionary mechanisms operating in a species which, by virtue of its social structure, is in other respects unfavorable for studies of changes in its genetic composition.—A. C. Gabriel. Genetic types in teeth. *Essays in Biology* (Sydney, Australia, 1948, pp. 7-61).

# THE SEX RATIO OF HUMAN STILLBIRTHS AT EACH MONTH OF UTEROGESTATION AND AT CONCEPTION

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## ONE FIGURE

It is well known that more males than females die, for one reason or another, during the uterogestation period. Strandskov ('45) found that among the 1,147,226 stillbirths reported for the U. S. Birth Registration Area from 1922 to 1936, inclusive, 656,005 or 57.18% were males. This is a deviation from equality which can not be attributed to chance alone. The percentages of males for stillbirths reported for many other human populations are of the same general order of magnitude.

Since stillbirths (the term is used here to include abortions) occur at all stages of uterogestation, it becomes of interest to know whether the sex ratio is constant for the different months or whether variations occur. This question has been investigated to some extent by Bodio (1895), Rauber ('00), Lenhossek ('03), Heape ('09), Jendrassik ('11), Schultz ('18), Parkes ('26), Greulich ('31), Ciocco ('38) and others. The last two mentioned investigators have presented percentages of males for stillbirths at each month of uterogestation which were based on fairly extensive data from the restricted region of the U. S. Birth Registration Area.

The data which we have selected for consideration also represent stillbirths which occurred in the restricted region of the U. S. Birth Registration Area. In this region early stillbirths, as well as later ones are supposed to be reported.

We appreciate, of course, that not all are reported, especially early abortions, but the available data appear to be sufficiently complete and reliable to warrant an analysis. The years we have selected for consideration are from 1922 to 1936 inclusive.

The restricted region of the U. S. Birth Registration Area includes, for the years which are considered, the states of Connecticut, Illinois, New Jersey, New York, Oregon, Utah and Washington, the District of Columbia, and the city of Baltimore, and for some years a few additional states.

The statistical formula which we have applied has been the usual one for a test of significance of the difference between two means.

$$t = \frac{\Delta}{\sqrt{\frac{\sum (X_1 - \bar{X}_1)^2 + \sum (X_2 - \bar{X}_2)^2}{N_1 + N_2 - 2}} \times \frac{N_1 + N_2}{N_1 N_2}}$$

All the  $t$  values obtained allow 28 degrees of freedom. Hence any  $t$  value of two or more has a probability of .05 or less, and may, therefore, be considered indicative of a difference which cannot reasonably be attributed to chance alone.

Table 1 presents the total number of stillbirths for which sex and month of uterogestation were reported, the number of male stillbirths and the mean of each of the 15 yearly percentages of males for each of the different months of uterogestation. The means are represented graphically in figure 1. From an inspection of table 1 or figure 1 it may be seen that the percentage of males is high for the first three months which are combined (78.610), decreases for the next 4 months to 53.529 for the 7th month, and then increases up to 57.844% males for the 10th month. These percentages agree closely with those obtained by Greulich and Ciocco, as they should, since all three sets of percentages involve some of the same data.

As we indicated earlier in the paper we have tested the means of the different percentages of males for significance



TABLE 1

*Total number of stillbirths for which sex and month were reported, number of male stillbirths and the mean of 15 calculated yearly percentages of male stillbirths for each of the different months of uterogestation. Data from restricted area reported by U.S. Bureau of the Census, 1922 to 1936, inclusive.*

MONTH OF UTERO- GESTATION	TOTAL NO. OF STILLBIRTHS	NO. OF MALE STILLBIRTHS	MEAN OF THE 15 YEARLY PERCENTAGES OF MALE STILLBIRTHS
Under 4th	4,519	3,539	78.610
4th	9,408	6,289	67.065
5th	18,207	10,627	58.574
6th	26,021	14,341	55.089
7th	33,513	17,923	53.529
8th	42,151	23,282	55.204
9th	99,054	56,909	57.324
10th	3,707	2,135	57.844
Total period	236,580	135,045	57.078

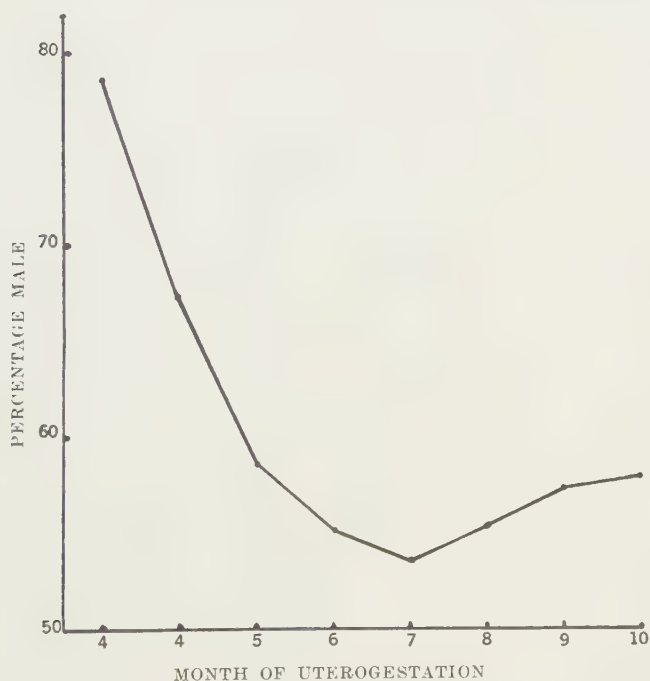


Fig. 1 Percentage of males among stillbirths at each month of uterogestation.

of difference. The  $t$  values obtained are shown in table 2. From an inspection of this table it may be seen that the mean of each month differs significantly from the mean of its preceding month (10th month excepted). Most of the

TABLE 2

*The  $t$  values obtained from comparisons of the means of the 15 yearly percentages of male stillbirths for the different months of uterogestation*

MONTHLY PERIODS OF UTEROGESTATION COMPARED <sup>1</sup>	DIFFERENCES BETWEEN MEAN PERCENTAGES	$t$ value
<i>Under 4th</i> vs 4th	11.55	13.2
<i>Under 4th</i> vs 5th	20.04	23.3
<i>Under 4th</i> vs 6th	23.52	31.1
<i>Under 4th</i> vs 7th	25.08	32.6
<i>Under 4th</i> vs 8th	23.41	31.1
<i>Under 4th</i> vs 9th	21.29	29.2
<i>Under 4th</i> vs 10th	20.77	19.6
<i>4th</i> vs 5th	8.49	11.7
<i>4th</i> vs 6th	11.98	20.0
<i>4th</i> vs 7th	13.54	21.9
<i>4th</i> vs 8th	11.86	19.8
<i>4th</i> vs 9th	9.74	17.2
<i>4th</i> vs 10th	9.22	9.7
<i>5th</i> vs 6th	3.49	6.0
<i>5th</i> vs 7th	5.05	8.4
<i>5th</i> vs 8th	3.37	5.8
<i>5th</i> vs 9th	1.25	2.3
<i>5th</i> vs 10th	.73	0.8
<i>6th</i> vs 7th	1.56	3.6
<i>6th</i> vs 8th	1.12	0.3
<i>6th</i> vs 9th	2.34	6.2
<i>6th</i> vs 10th	2.76	3.2
<i>7th</i> vs 8th	1.68	3.9
<i>7th</i> vs 9th	3.80	9.7
<i>7th</i> vs 10th	4.32	5.0
<i>8th</i> vs 9th	2.12	5.9
<i>8th</i> vs 10th	2.64	3.1
<i>9th</i> vs 10th	.52	0.6

<sup>1</sup> The monthly period with the larger percentage is italicized.

other comparisons also indicate a significant difference. As might be expected a few of the means on the descending slope of the curve are not significantly different from some of those on the ascending side.

The analysis presented so far has been based on the data for which both the sex and the uterine age of the stillborn fetuses were reported. The total stillbirth data for the region and time interval under consideration include some stillbirths for which the uterine age is indicated but for which the sex is not reported. They also include some stillbirths for which the sex is stated but for which the uterine age is not indicated. And finally they include a few for which neither sex nor uterine age is reported. We wish to utilize the total number of stillbirths together with the total number of live births for a determination of the percentage of those alive at the beginning of the month which died during the month. In order to be able to do this we have distributed or allocated the incompletely reported data in as logical a manner as seems possible. We appreciate that the allocation is not entirely satisfactory but we believe that we have approximated the true picture. The figures are shown in table 3. Attention may be called to the fact that the percentages of males for the different months of uterogestation which were obtained for the completely reported data, were used as a basis for the calculation of percentages of males for the incompletely reported figures. Therefore the monthly percentages of male stillbirths remain the same. This, however, is not true of the proportions of all stillbirths which occurred at each month, because a higher proportion of month known but sex unknown data were reported for the earlier months than for the later ones and therefore had to be allocated to the early months. If any discrepancy exists it is in not allocating quite enough of the month unknown stillbirths to the earlier months.

As we stated above we are interested in combining the total number of reported stillbirths with the total number of reported live births in order to calculate the percentage

of deaths or the selection pressure at each month of uterogestation. The number of reported live births was 7,437,854, of which 3,798,128 or 51.065% were males. Hence the total number of conceptions about which we have information was 7,723,922, of which 3,962,829 or 51.31% were reported to be or have been estimated to be males.

Table 4 shows the number of fetuses which are known to have been implanted or to have existed at the beginning of

TABLE 3

*Total (given and allocated) numbers of stillbirths and the percentage of males among stillbirths for each month of uterogestation. Data from restricted region of U. S. Birth Registration Area, 1922 to 1936, inclusive.*

MONTH OF UTERO- GESTATION	STILLBIRTHS		
	♀ and ♂	♂	♂
	no.	no.	%
Under 4th	11,571	9,096	78.610
4th	12,322	8,264	67.065
5th	21,889	12,821	58.574
6th	30,781	16,957	55.089
7th	39,469	21,127	53.529
8th	49,512	27,324	55.204
9th	116,168	66,592	57.324
10th	4,356	2,520	57.844
Total	286,068	164,701	57.574

the second month of uterogestation, the number and the percentage which died during the second and third month, and so on for the remaining months. The number left over at the end of the last month is, of course, the number of reported live births. The same procedure is followed for the actual plus the estimated numbers of females and males for each month of uterogestation.

From an inspection of table 4 it may be seen that the selection pressure against fetuses increases with each month of



uterogestation, reaching its peak at full term. It seems probable that it is considerably higher for the very early months than the figures show, but the data as reported do not actually give evidence of it. Table 5 gives the number of times greater that the selection pressure was for one month than for another. The greatest difference between successive

TABLE 4

*Numbers alive at the beginning of and the number and percentage stillborn during the various months of uterogestation. Data from restricted region of the U. S. Birth Registration Area, 1922 to 1936, inclusive*

	FEMALES AND MALES		FEMALES		MALES	
	no.	%	no.	%	no.	%
Known implanted	7,723,922		3,761,093	48.694	3,962,829	51.306
Died 2-3rd mo.	11,571	.150	2,475	.066	9,096	.223
Alive end 3rd mo.	7,712,351		3,758,618	48.735	3,953,733	51.265
Died 4th mo.	12,322	.160	4,058	.108	8,264	.209
Alive end 4th mo.	7,700,029		3,754,560	48.760	3,945,469	51.240
Died 5th mo.	21,889	.284	9,068	.242	12,821	.325
Alive end 5th mo.	7,678,140		3,745,492	48.781	3,932,648	51.219
Died 6th mo.	30,781	.401	13,824	.369	16,957	.431
Alive end 6th mo.	7,647,359		3,731,668	48.797	3,915,691	51.203
Died 7th mo.	39,469	.516	18,342	.492	21,127	.540
Alive end 7th mo.	7,607,890		3,713,326	48.809	3,894,564	51.191
Died 8th mo.	49,512	.651	22,188	.598	27,324	.702
Alive end 8th mo.	7,558,378		3,691,138	48.835	3,867,240	51.165
Died 9-10th mo.	120,524	1.595	51,412	1.393	69,112	1.787
Live born	7,437,854		3,639,726	48.935	3,798,128	51.065

months is between the 8th and the last two months combined, and the second greatest between the 4th and 5th months. The greatest difference between any two months is, as shown, between the first combined group of second and third months and the combined 9th and 10th months.

Tables 4 and 5 also indicate a difference between sexes with respect to selection pressure. The selection is greater

TABLE 5

*Number of times that the effect of the selection pressure is greater for one month of uterogestation than for another. Based on data from restricted region of U. S. Birth Registration Area, from 1922 to 1936, inclusive*

UTEROGESTATION MONTHS COMPARED <sup>1</sup>	♀ ♂	♀	♂
Under 4th vs 4th	1.07	1.64	0.94
Under 4th vs 5th	1.90	3.67	1.42
Under 4th vs 6th	2.68	5.61	1.88
Under 4th vs 7th	3.45	7.47	2.35
Under 4th vs 8th	4.34	9.08	3.06
Under 4th vs 9 + 10th	10.64	21.17	7.78
4th vs 5th	1.79	2.24	1.56
4th vs 6th	2.51	3.42	2.06
4th vs 7th	3.23	4.55	2.58
4th vs 8th	4.07	5.53	3.36
4th vs 9 + 10th	9.98	12.90	8.55
5th vs 6th	1.41	1.53	1.33
5th vs 7th	1.81	2.04	1.66
5th vs 8th	2.29	2.47	2.16
5th vs 9 + 10th	5.61	5.77	5.50
6th vs 7th	1.29	1.33	1.25
6th vs 8th	1.62	1.62	1.62
6th vs 9 + 10th	3.98	3.77	4.14
7th vs 8th	1.26	1.22	1.30
7th vs 9 + 10th	3.09	2.83	3.31
8th vs 9 + 10th	2.45	2.33	2.55

<sup>1</sup> The first month listed of the two months compared represents the one with the smaller percentage of stillbirths.

TABLE 6

*Number of times that the selection pressure for each month of uterogestation is greater against males than against females. Based on data from restricted region of U. S. Birth Registration Area, 1922 to 1936, inclusive*

MONTH OF UTEROGESTATION	% ♀ STILLBIRTHS
	% ♂ STILLBIRTHS
Under 4th	3.38
4th	1.94
5th	1.34
6th	1.17
7th	1.10
8th	1.17
9 + 10th	1.28

at every month against males. The extent to which it is greater for each month is indicated in table 6. The relative selection pressure against the male is shown to be greatest for the combined first three months, lowest for the 7th month, and relatively high again at or near full term.

So far we have only alluded to the conception sex ratio of the population in question. We appreciate that our data do not allow a final statement regarding this question, but our data appear to be sufficiently complete to give hints of what it may have been in the population in question, or what it is in human populations in general.

From all indications sex in man is completely genetically determined. By this statement we mean merely that there apparently is a perfect correlation between genotype and phenotype. This conclusion is based primarily on the fact that the body cells of all human females which have been examined possess 2 X-chromosomes plus 23 pairs of autosomes, whereas those of all males possess an X- and a Y-chromosome, plus 23 pairs of autosomes (Winniwarter, '12; Painter, '23; Oguma and Kihara, '23; Evans and Swezy, '28).

If the above mentioned chromosome composition holds true for all males of the human species one should expect one-half of all sperms which are formed to carry an X-chromosome and one-half a Y-chromosome. Accordingly, assuming all other factors constant, one should expect a 50:50 conception sex ratio. Whether or not this ratio obtains has been the subject of considerable speculation. Among the individuals who have presented some early stillbirth data and who have ventured an estimate of the conception sex ratio are: Bodio (1895), Rauber ('00), Lenhossek ('03), Körösy ('08), Newcomb ('09), Auerbach ('12), Carvallo ('12), Schultz ('18), Parkes ('25), and Boldrini ('36). The estimates of these investigators have ranged from about 52 to 52.5% males. A few have argued for an even higher figure. All of these estimates are based on the percentages of males found among stillbirths which have reached the second, third, or 4th month of uterogestation.

Our data are no better than others which have been presented for an estimate of the conception sex ratio. Hence we can not give a satisfactory answer to the question at issue, but we should like to point out that we think that our data support the prevailing view that more males than females are conceived. The only other possible explanation for the observed results is that a much higher percentage of females than males die the first month or the first two months following conception. We doubt that this is true. At least we know of no data which support or even suggest this possibility. Our estimate of the conception sex ratio for the population in question lies somewhere between 51.3 and 52% males. This may be a little lower than that which actually holds true for some other populations. We consider it probable that differences occur between populations which are dependent in part upon environmental and in part upon genetic factors.

If more males than females are conceived in most if not all human populations, then it becomes necessary to account for this fact. Several hypotheses have been advanced. One is that sex linked lethal mutations occur which tend to kill off more female than male determining sperms before they reach the region of the unfertilized egg. Another is that X-carrying sperms, for reasons other than those indicated in the previous sentence, are more susceptible to the chemical environment of the female genital tract. A third hypothesis is that Y-carrying sperms are more mobile or penetrate the membranes of the unfertilized egg more readily than X-carrying sperms. Although any one or all of these hypotheses are attractive, we must admit that no specific data exist which support or favor any one of them.

What the causal factors are which result in a higher percentage of stillbirths for one month of uterogestation than for another, or why a higher percentage of males die during one month than during another are questions which deserve further investigation. We are examining such data as are available for probable clues.



In conclusion we should like to emphasize that we feel certain that only a small percentage of all stillbirths or abortions are reported for the first few months of uterogestation, even in the restricted region of the U. S. Birth Registration Area. Hence we should like to urge that the selection pressures calculated for these months be considered representative only of the reported stillbirths. On the other hand we think that the obtained percentages of males among stillbirths for each month of uterogestation are close to the true picture. Accordingly we think that the calculated relative selection pressures against males and females for each month should be close to reality.

#### SUMMARY

1. Numbers and percentages of males among stillbirths for the different months of uterogestation are presented. The data are for a restricted region of the U. S. Birth Registration Area from 1922 to 1936.

2. It is found that the percentage of males among stillbirths is highest for the combined second and third months (78.61), decreases for the next 4 months to 53.53 for the 7th month, and increases up to 57.84 for the 10th month.

3. The percentages of males among stillbirths for successive months are found to be significantly different.

4. Total numbers of reported live births and of stillbirths are combined to give total number of conceptions reported.

5. The number of fetuses present at the beginning of each month of uterogestation is calculated and presented together with the percentage of stillbirth for each month.

6. It is found that the percentage of those alive at the beginning of the month that die during the month increases with each month of uterogestation from a low of 0.51% for the first three months combined to a high of 1.60% for the 9th and 10th months combined. However, calculated percentages for the early months are probably not reliable.

7. Selection pressures against males and females are compared for each month. It is found that the highest relative pressure is against males during the earliest months, lowest during the 7th month and relatively high at or near full term.

8. The conception sex ratio in the population in question is estimated to lie somewhere between 51.3 and 52% males.

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NUTRITION AND TOOTH DECAY.—Conditions producing good general health were found [in Hawaii] to be associated with severe tooth decay, and conversely, poor health was associated with excellent teeth. Harrison's groove is probably not caused by rickets, and height and weight values must be related to specific age levels to be of most value.

Heavy carbohydrate eaters (Polynesians on taro) had excellent teeth, and heavy carbohydrate eaters (Orientals on rice) had extremely poor teeth.

Hawaiian waters are low in fluorine; sea foods are high in fluorine and can affect teeth. Hence, people in areas with water low in fluorine may have good teeth with high fluorine content.

Oxalates high in taro and low in rice may be one of the factors favoring immunity from decay.

The observations in Hawaii tend to verify the role of aciduric bacteria as an index of decay immunity and that oxalates and fluorides, as well as the alkaline residue food values in the Hawaiian diet, might account for decay resistance in certain groups in Hawaii. These factors are more important in preventing decay than climate, heredity, cleanliness of the teeth or specific food factors including sugar.

[By way of further illustration] 2 postwar Filipinos aged 3 years and 7 months and 4 years and 7 months, respectively, each had 20 perfect deciduous teeth. They ate rice (3 times a day), had a sweet cake of rice flour and molasses rolled in banana leaves (twice a week), taro (3 times a week), fruit and vegetables (4 times a day), meat (twice a week) and candy (once a day); they chewed sugar cane frequently. They drank no milk. Nils P. Larsen. Tooth decay in relation to diet and general health. *J. Am. Med. Assoc.*, vol. 137, no. 10, July 3, 1948, pp. 832-838.

PROPOSED INTERNATIONAL ANATOMICAL CONGRESS.—An invitation has been extended to members of the American Association of Physical Anthropologists to attend an International Anatomical Congress which has been tentatively scheduled to meet in Oxford, England, from Tuesday, July 25th to Friday, July 28th, 1950. These dates have been selected in order that the attendance at the XVIII International Physiological Congress, which is being held at Copenhagen from 15th to 18th August may not be adversely affected. Probably included in the program will be a section on physical anthropology.

The accommodations for the majority of the members will be provided in Colleges by the Congress Office, and it will therefore be essential that those who intend to be present should intimate the fact not later than the date which will be indicated for this purpose, in order that the correct number of rooms may be reserved. Details on this and other points will be furnished at a later date when the actual invitations are issued. Communications should be addressed to Graham Weddell, Congress Secretary, Department of Human Anatomy, University Museum, Oxford, England.

MATURING VS. AGING.—Maturity is customarily regarded as a state or fixed condition to which the juvenile organism approximates when reaching the adult years. Maturation has, therefore, been interpreted normatively, with more or less rigid criteria based on chronological age. But maturation, like aging, is an ongoing process, operating in gestation, infancy, childhood and adolescence, indeed, throughout the life career in the continuous biological transformations and progressive integrations through which the organism attempts to meet the tasks of life and of social and interpersonal requirements.

Maturity, in this view, becomes not a fixed goal or state, but rather the successive approximations to adequacy of functioning and of conduct whereby the individual progresses from conception to death. We may speak, then, of an infant being more or less mature (or premature) according to his capacity to meet life on an infantile level of adequacy, or of a child or adolescent being mature on the successive levels of biological, social and personal adequacy.

Maturing might then be conceived as the melody of living played against the bass of aging in the counterpoint of life. The organism's approach to progressive enhancement of living on each successive level is balanced, reinforced, checked, or overcome by the cumulative and insistent process of aging which brings impairments and dysfunctions that undermine his integrity and organic equilibrium.—Lawrence K. Frank. *Gerontology*. *J. Geront.*, vol. 1, no. 1, pt. 1, 1946, pp. 5-6.



# THE RELIABILITY OF THE PHOTOGRAMMETRIC METHOD OF ANTHROPOMETRY, WITH A DESCRIPTION OF A MINIATURE CAMERA TECHNIQUE

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WITH AN ADDENDUM ON AN AIRCRAFT CAMERA TECHNIQUE

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FIVE FIGURES

## INTRODUCTION

Though photography has been used as an aid in anthropological studies since its inception, that it should stand largely or entirely by itself as a method of accurate anthropometry is a fairly recent proposal, introduced chiefly by Sheldon ('40). That it has advantages over the classical techniques cannot be denied; the outlines of a photograph do not move as they are measured, and to the photogrammetric calipers the softest tissue becomes as incompressible as bone. Standardised photographs take but a couple of minutes to obtain, yet provide as many measurements as the unhurried observer can reliably devise. Above all — for though measurements cannot lie, they can be deceptively irrelevant — a permanent record of the subjects' actual appearance becomes available, rather than, or in addition to, a collection of figures and checkings; leisurely scrutiny suggests additional questions, and additional questions direct further measurements.

There are, of course, disadvantages. There may be virtue in measuring diameters composed of a single tissue, and

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there exists a vast literature to which the new photogrammetric results may be superficially incomparable. All the same, if validity means anything in anthropometry, it must be taken to connote the directness of relationship between the measurements taken and the subjects' genes: or, in special instances, between the measurements and particular environmental stresses such as starvation. And it is by no means clear that the classical measurements do have the advantage in this respect; probably the somatotype or the factorial analysis factors of physique have the closest relation to the genes (Tanner, '47) and a comparison of the effectiveness of estimation of the various factors from the living and from the photographic measurements has not yet been carried out.

Meanwhile, there remains one criterion by which the two sets of measurements may be compared; and this is their relative reliability, their repeatability from one occasion to another. Strangely enough, despite and perhaps because of the profusion and variety of measurements on the living, there are very few studied reports of their reliability; perhaps this is one of the reasons for the long-continued difficulty in securing agreement as to which measurements are preferable. The present study was made with the express intention of preventing the same occurrence in photogrammetry, as well as to see whether in general photographic measurements were as reliable as living ones.

There are, of course, many possible photographic setups, and most of our analysis, both of measurement error and of photographic technique applies, more or less, to them all. However, we adopted at one period, and here describe, a 35 mm camera technique. Its chief advantages are that a stock of loaded cassettes enables photography to be carried on continuously for an indefinite period away from a dark-room; that the cheapness of the film enables three separate negatives to be used for the three views, making unnecessary the construction of the special back needed with a portrait camera; and that the equipment is easily transportable and the cassettes readily sent by mail or stored. All these points

make the miniature camera ideal in many ways for anthropological field work and for survey work involving large numbers of pictures in a short time; the present technique was in fact evolved to meet this latter situation in studying ambulatory hospital patients (Tanner and Jones, '48). The chief disadvantage is the small size of the negative, discussed below. Recently, with the help of Dr. Stanford a photographically superior technique using an aircraft camera and flash lighting has been evolved, and we now use this for hospital work and wherever a relatively permanent set-up is envisaged. This equipment, which is described in detail in the addendum to this paper, is too large to be easily transportable, requiring a small truck rather than a private car.

#### MATERIAL AND METHODS

The material consisted of 70 male adults, all Royal Navy personnel. Their mean age was 25.6 years, with a standard deviation of 3.4 years. All were in good health.

The subject stripped, and was weighed by a technical assistant. He then went to investigator W, who marked the skin over certain bony points with Indian ink. W then measured and read off to a recorder stature, sitting height, biacromial diameter, anteroposterior chest diameter and circumference of neck, upper arm, lower arm, wrist, thigh, calf and ankle. Stature, biacromial diameter, and anteroposterior chest were taken in the manner described by Hooton ('46); sitting height with the subject sitting on a bench with thighs horizontal and lower legs vertical, feet on the ground, posterior aspect of back making contact with the upright of the height scale at the sacral and upper thoracic region, but the head not necessarily in contact. Neck circumference was taken with the tape kept in a plane at right angles to the longitudinal axis of the neck, in the hollow below the most prominent part of the thyroid cartilage. The tip of the left acromion, the left radiale and a point half-way between them had been marked on the skin, and upper arm circumference was taken at this half-way level, perpendicular to the long

axis of the limb. Lower arm circumference was the maximum forearm circumference taken perpendicular to the long axis, and the wrist circumference was the minimum, taken just above the styloid process of the ulna. The thigh measurement was taken with the upper edge of the tape against the line where the posterior fold of the buttock curves into the posterior surface of the thigh. The circumference of the calf was taken at its maximum, with the left foot on a chair, the calf muscles relaxed. Ankle circumference was the minimum above the malleoli; all these leg measurements were taken perpendicular to the long axis of the limb. Leg length was later calculated as stature minus sitting height, and this, following Hrdlička ('39), we call subischial length.

These measurements were then promptly repeated, on all except the first 5 subjects. After no. 25 (i.e., for the remaining 40 subjects) an attempt was made to rule out the possibility of remembering the first set of figures: in the biacromial and anteroposterior chest measurements the recorder read the scale and silently wrote down the figures on the first occasion, so that W never looked at them. In taking the circumference W read off to the recorder the first time "40 — 6.3," for example, and the second, shifting his base-line on the tape, "35 — 1.5." The subtractions were all done later.

When this routine was finished, the subject crossed over to investigator T, who measured bideltoid, bitrochanteric, bicondylar diameters of humerus and femur, and subcutaneous tissue folds, in that order. The bideltoid measurement was taken with the subject standing as for biacromial, with the Hrdlička caliper blades over the tuberosities of the humeri, slight pressure being used: it is not considered a very accurate measurement, owing to difficulty as to the precise level at which it should be taken. Bitrochanteric diameter was taken with the Hrdlička calipers, with slight pressure over the trochanters, the subject standing with legs together and feet parallel. The bicondylar diameters were taken as described by Meredith ('35). The subcutaneous tissue measurements were taken with the Franzen ('29) calipers; upper arm front,



midway between acromion and radiale at the previously marked point, blades parallel to long axis of limb: upper arm back, same level, arm hanging relaxed: thorax front, xiphoid level, half-way between nipple line and anterior axillary line, blades horizontal: thorax back, xiphoid level below the inferior angle of the left scapula, blades at angle of 45 degrees to vertical: supriliac, just above the crest of the left ilium in the anterior axillary line, blades at 45 degrees to vertical. Subcutaneous thigh was attempted and abandoned. All measurements not crossing the midline were taken on the left side of the body, and all recorded to the nearest millimeter.

The subject then went to the photographic turntable, was posed by T, and photographed in front, side, and back views using the lighting plan as shown in figure 1, the Leica camera lens at 10 metres from the centre point of the turntable, with a Hektor 13.5 cm focal length lens, at  $f/4.5$  with microfilm and  $1/8$  second exposure (series A). This photographic technique is discussed, with reference to the 10 metre distance, type of film, etc., later in this paper. The posing of the subject followed the directions of Sheldon ('40) except in the front view where the forearms were supinated into the anatomical position, and the hand placed so that its long axis continued the long axis of the arm, with the thumb extended to make possible a hand width measurement<sup>2</sup> (see fig. 2). T then repeated the subcutaneous measurements on the subject. It was found that only about one in 10 or less of the subcutaneous measures could be remembered, because 7 of them were originally taken and there was about a three-minute interval between the measurements. Frequently it could be recalled that such and such a measurement had been either 9, 10 or 11 mm, but this was of no material assistance. The subject again stepped onto the turntable, was again posed by T, and again photographed at 10 metres, using microfilm,  $f/4.5$ ,  $1/8$  second (series B). Without stepping off the turntable, the subject

<sup>2</sup> We no longer use this pose, nor recommend it. A detailed description of a pose we hope will be generally adopted as standard in all photogrammetry and somatotyping has recently been put in press by W. C. Dupertuis and J. M. Tanner.

was then photographed at 10 metres using Panatomic X film f/5.6, 1/30 second and the same lighting (series C).

The films were developed in Kodak DK 20, the Panatomic for 16 minutes at 65°F. and the microfile, for 8 minutes, which reduced the unwanted contrast. On a vertical arm attached to the base on which the turnable revolved were pointers set exactly 1 metre apart, and on the base itself vertical pointers

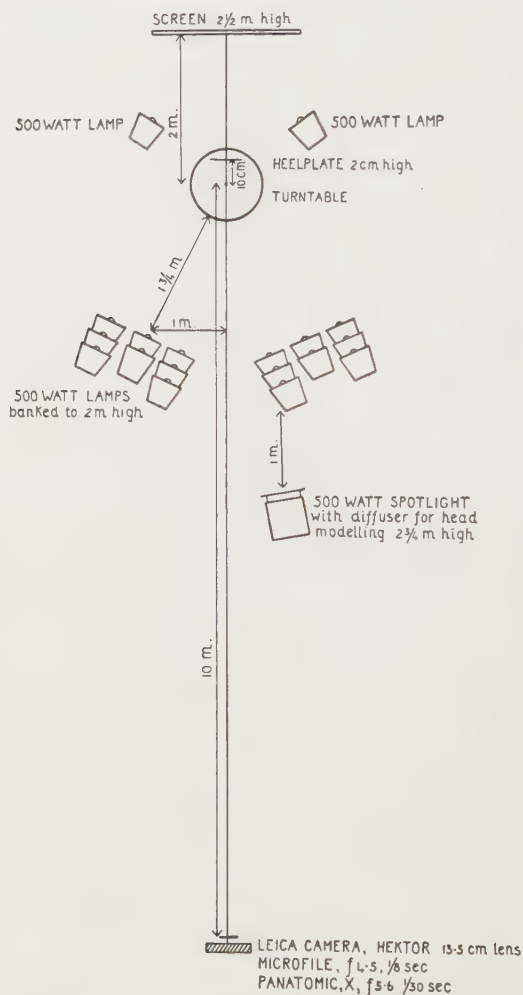


Fig. 1 Lighting plan for Leica with microfile.

$\frac{1}{2}$  metre apart each in the plane of the centre of rotation of the turntable. Using an Elmar 9 cm lens in a Focomat enlarger, prints were made on normal contrast Waterproof Base nonshrink paper, and air dried, so that the 1 metre distance became exactly 120 mm; that is, the enlargement is about  $\frac{1}{8}$  natural size, the actual conversion factor being 8.33. All the photographs were processed without further resetting of the enlarger. In this particular experiment, due to the source and size of our enlarging paper, a separate enlargement of each negative was made and the three views dry-mounted onto a  $12'' \times 10''$  mount so that all could be seen easily at once. Usually however, we use  $12'' \times 10''$  paper and an enlarger screen so arranged that one-third of the paper can be exposed at a time, this third being always vertically under the negative (i.e., the paper holder is moveable on rails, with appropriate stops). This arrangement, which is the one we recommend, may also be combined with a film-gate in the enlarging apparatus, if desired, making the entire procedure very rapid and quite automatic: 100 enlargements can be made per day by two men working together, even without the gate. In the present experiment the head and shoulders region of series A and B were also enlarged 18 diameters for special study. This is just double the routine whole body enlargement, which works out at about 9 diameters.

Measurements of the various body diameters shown in figure 2 were then made: these are the measurements used by Sheldon, with a few additions and slight modifications mentioned below. A specially designed instrument, shown in figure 3, was used, and proved extremely convenient. It is an ordinary pair of calipers, with a lever arm  $\times 5$  enlargement, scale graduated to  $\frac{1}{10}$  mm, and sharp immovable points. The calipers<sup>3</sup> illustrated only measure up to 30 mm; we also use a larger pair which measure up to 50 mm, as much as is routinely necessary. We do not find a magnifying glass necessary, and measurements can be taken at the rate of between

<sup>3</sup> Obtainable from Quadrant Engineering Co., Ltd., Imperial Works, Perren St., London N.W. 5, England. This firm also makes subcutaneous tissue calipers.

one and one-half a minute, depending on the dimension taken and on the measurer. Measurements are recorded to the nearest  $\frac{1}{10}$  mm which corresponds to slightly under 1 mm on the living body, thus meeting the criteria laid down by Tildesley ('47). A gridded screen behind the subject or in front of the lens was not used, but is recommended as we feel it would have materially helped us to keep horizontal measurements horizontal.

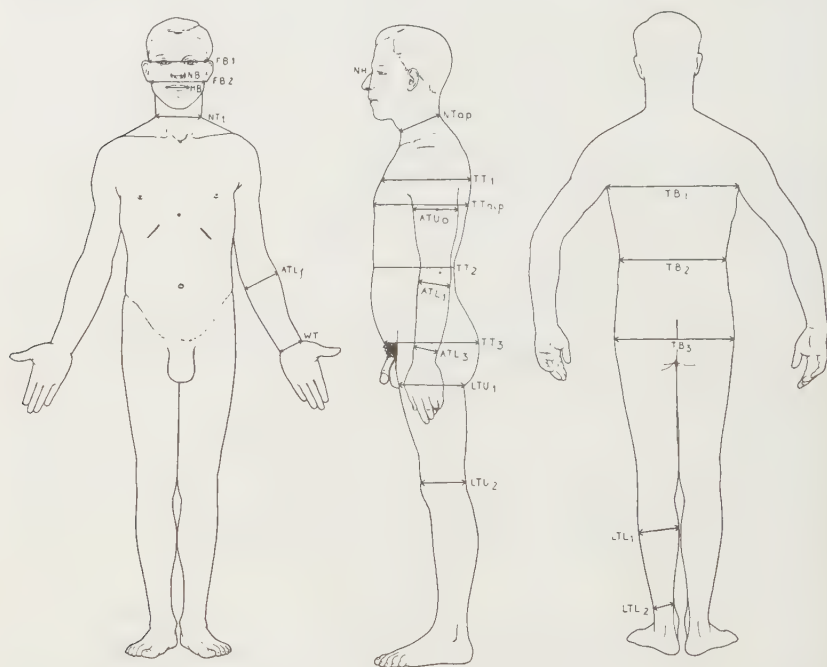


Fig. 2 Measurements taken from photograph. Left: front view; middle: side view; right: back view.

All the measuring of the photographs was carried out by investigator T and technician J, as follows: J measured and recorded the first measurement NTt, on the 70 photos of series A (microfile, first posing). He then did the same for the second measurement NTap. He then remeasured (without, of course, seeing his previous results) NTt series A, then NTap series A. NTt series B (microfile, second posing) was then



measured, and NTap series B; then NTt series C (panatomic X), NTap series C, and once again NTt series C, and NTap series C. Measurements on which full data are available below were worked through in pairs this way, and finally investigator T measured series A once for each measurement, and did some further measurements of series A and B to



Fig. 3 Photogrammetric calipers.

compare them (the incompletely presented data at the bottom of table 3). Care was taken not to make pin-pricks on the enlargements which could serve as guides in subsequent measurements.

Before the final calculations were begun all the recorded figures were checked through and a small number of changes of an editorial nature were made. Changes were made only in instances where there had quite clearly been erroneous

copying or recording of figures; for example, two figures of 21.6 and 31.4 for consecutive measurements, when the difference in the other 69 cases was of the order of .2. In no instance was any change made where there was a doubt as to whether faulty recording or an outlying but genuine value was concerned. The total number of such editorial changes was 38, out of approximately 9300 records, that is 0.4%. This is considerably fewer than similar corrections made by Shuttleworth in his analysis of the Harvard Growth Study data ('37, appendix A), which is to be expected, considering the larger number of observers concerned in collecting the latter.

#### RESULTS AND DISCUSSION

We will consider first the figures bearing on the reliability of this technique. Next we discuss some aspects of the photographic technique, and finally the relations between some of the photographic dimensions and the corresponding measurements taken on the living body.

##### *Reliability of photogrammetry*

Suppose a single observer measures a single dimension twice on each of 70 subjects. There are two possible ways in which he may most effectively report the reliability of his measurement, and both appear in the literature. He may subtract, algebraically, one series of his 70 readings from the other series and obtain a series of 70 differences, some plus, some minus, probably averaging very close to zero. He then calculates the standard deviation of these differences,  $\sigma_d$ , in the usual way and reports this. He probably also gives  $\sigma_d$  in per cent of the mean value of the dimension considered.

The second way requires somewhat more arduous calculations. The observer may calculate the coefficient of correlation between his two series of 70 measurements, this coefficient being known as the coefficient of reliability if one observer only is concerned, and as the coefficient of objectivity if each of the two series is taken by a different

observer. This figure, which we will call  $r_{12}$ , where the subscripts refer to first and second time of measuring, is directly useful for comparing the accuracy of measurement for a whole series of dimensions, and in factor analysis work: the quantity  $1 - r_{12}^2$  gives directly the proportion of the total variability of a dimension due to measuring error. From  $r_{12}$  the observer may then calculate what he probably chiefly requires to know, namely, how close to his first measurement subsequent remeasurements are likely to be. Two ways are open to him. He may proceed in the usual way to calculate the standard error of estimate,  $\sigma_{\text{est}}$ , by the formula

$$\sigma_{\text{est}} = \sigma_1 \sqrt{1 - r_{12}^2}$$

It will be appreciated that this figure  $\sigma_{\text{est}}$  is not identical with  $\sigma_d$  of the previous method since more of the variability due to using different people enters into  $\sigma_d$  than  $\sigma_{\text{est}}$ . The relations between them can be worked out very simply from the relation

$$r_{12} = \frac{\sigma_1^2 + \sigma_2^2 - \sigma_d^2}{2\sigma_1\sigma_2}$$

The expression is rather lengthy unless we assume  $\sigma_1 = \sigma_2$ , which is very nearly the case in practice, and if we do so, then

$$\sigma_{\text{est}}^2 = \sigma_d^2 - \frac{\sigma_d^4}{4\sigma_1^2}$$

Thus  $\sigma_{\text{est}}$  is always less than  $\sigma_d$ , and increases as  $\sigma_d$  increases, albeit more slowly.

Neither  $\sigma_d$  nor  $\sigma_{\text{est}}$ , however, gets closest to what we may consider the essence of reliability, that is, how much further measurements on one and the same person will vary about the "true" value, the value obtained by taking the mean of an infinite number of readings. The statistic which perhaps best expresses this is  $\sigma_{\text{meas}}$ , the standard error of measurement (Peters and van Voorhis, '39). The formula for it is

$$\sigma_{\text{meas}} = \sigma_1 \sqrt{1 - r_{12}}$$

and the interpretation is, as usual, that 95% of subsequent measurements of the given dimension will fall within  $\pm 2 \sigma_{\text{meas}}$

TABLE 1

*Reliability coefficients of anthropometric and photogrammetric measurements*

AUTHOR, MEASUREMENT AND MATERIAL	PRESENT STUDY	MEREDITH	MARSHALL	FRANZEN	KNOTT
	1 observer 65-70 adults	('36) 1 observer 25 8-10 yr. olds 7 times each	('37) 2 observers 25 8-10 yr. olds 6 times each	('29) 2 observers 200 11 yr. olds	('41) 2 observers ca. 150 3-6 yr. olds
<i>Dimension</i>					
Stature	.997	.993	1.00	.99	.997
Sitting height	.986	.974	.97	..	.987
Subischial length	.994	...	..	..	.985
Biacromial	.956	.819	.80	.94	.952
A.P. chest	.977	...	..	.96	.928
Trans. chest	...	...	..	.91	.958
Chest circum.	...	.977	.97	..	.971
Bitrochanteric	...	.982	.96	.98	...
Bicristal	...	.994	.98	..	.987
Circum. neck	.940	...	..	..	....
Circum. upper arm	.977	.986	.97	.99	.979
Circum. forearm	.963	.972	.95	..	.984
Circum. wrist	.928	...	..	..	...
Circum. thigh	.984	.978	.97	..	.986
Circum. calf	.982	.991	.97	.99	.993
Circum. ankle	.973	..	..	..	...
Subcut. upper arm front	.955	...	..	.94	...
Subcut. upper arm back	.982	.948	.84	.94	.857
Subcut. thorax front	...	...	..	..	.906
Subcut. thorax back	.968	.941	.93	..	.884
Subcut. suprailiac	.975	.940	.93	..	.873
NTap	.987				
NTt	.974				
TT <sub>1</sub>	.955				
TTnip	.967				
TT <sub>2</sub>	.972				
TT <sub>1</sub>	.985				
TB <sub>1</sub>	.935				
TB <sub>2</sub>	.999				
TB <sub>3</sub>	.988				
ATU <sub>1</sub>	.974				
ATL <sub>1</sub>	.844				
ATL <sub>1</sub>	.905				
LTU <sub>1</sub>	.981				
LTU <sub>2</sub>	.968				
LTL <sub>1</sub>	.987				
LTL <sub>1</sub>	.952				
FB <sub>2</sub>	.981				



of the "true" value. The relation of  $\sigma_{\text{meas}}$  and  $\sigma_d$  is of considerable interest, and if we assume once more  $\sigma_1 = \sigma_2$  it is very simple, namely

$$\sigma_d = \sqrt{2} \cdot \sigma_{\text{meas}}$$

Thus the more simply calculated  $\sigma_d$  gives the same information as  $\sigma_{\text{meas}}$ , since it is directly proportional to it, but is nearly one and one-half times as large (cf., Dahlberg, '26, p. 197). In the present paper,  $r_{12}$  is reported in table 1, and  $\sigma_d$  in table 2, where  $\sigma_1$  is also given to enable any further calculations to be made.

Besides the coefficient of reliability of our own measurements between series A and B, (1 observer, 2 posings), table 1 gives reliability or objectivity figures for the other authors who have made fairly extensive studies; for these latter only similar dimensions to ours are listed, and others will be found in their original papers.<sup>4</sup> It will be seen that agreement on the relative accuracy of the living body measurements is good, with the exception of the biacromial values of Marshall and Meredith, which were taken with the subject standing with shoulders pulled back, an evidently poor technique. Both age and observer differences seem to become considerable only in the case of the subcutaneous measurements. Our main question, however, is how to do the photogrammetric dimensions compared with the others? In general there is very little to choose between them. For neck measurement, the photo is clearly better, for biacromial a shade worse. It seems that it is the bodily dimension itself which chiefly determines the accuracy with which it can be measured. However, there are some exceptions such as  $ATI_{11}$ , and we will now consider in greater detail the accuracy of photogrammetry, using this time  $\sigma_d$  as our measure. The differences  $d$  considered algebraically are distributed, of course, following a normal curve: and the curve that results when they are ordered without regard to sign is merely a normal one folded upon itself about

<sup>4</sup> See also Bakwin and Bakwin ('31) and Bayley and Davis ('35) for infants, O'Brien, Girshick and Hunt ('41, pp. 23-27) and the excellent study of roentgenographic facial profile measurements of Björk ('47), where reliability is reported in terms of  $\sigma_{\text{mens}}$ .

the vertical axis (Dahlberg, '26). Failure to appreciate this is apparently responsible for the use by the Iowa investigators of median differences instead of the more precise and more conventional  $\sigma_d$  (Knott, '41, p. 45; Meredith, '36; Marshall, '37).

*The sources of inaccuracy in photogrammetry.* The experiment was designed so that the three main sources of error, namely that of measuring the photograph, of posing the subject, and of differing observers could be separated out and assessed. The results are set forth in table 2, where the means, standard deviations and variances are recorded as photographic measurements, which should be multiplied by the appropriate factor to bring them to actual distances on the person. It will be recalled that series A pictures were measured twice by J, and the variance of the differences between these two series  $A_{J1}$  and  $A_{J2}$  is given as variance  $a$ , column 5, this is the figure  $\sigma^2_{dAJ1 - AJ2}$ . Posing was also done twice, and J also measured this second posing series B. Lastly T, as well as J, measured the series A. Now if we assume that errors of measuring, errors of posing, and errors by virtue of being different observers are independent of each other, we have

$$\sigma^2_{tot} = \sigma^2_a + \sigma^2_b + \sigma^2_c$$

where the subscripts refer *tot* to total variance,  $a$  to measuring,  $b$  to posing and  $c$  to observer. This assumption is likely to be not quite true in practice since bad posing, for example, might increase both posing error  $b$ , and, by virtue of making identification of landmarks more difficult, measuring error  $a$  as well. However, the extent of correlation of this sort is not likely to be high, and certainly not high enough to invalidate the main trend of our figures.

The three variances on the right hand side of the above equation are estimated very simply.  $\sigma^2_a$  is obtained directly, as already described.  $\sigma^2_b$ , the posing variance, seen in column 6, is the difference between J's readings of series A and B, minus J's measurement error; that is  $\sigma^2_{dAJ1 - BJ1} - \sigma^2_{dAJ1 - AJ2}$ .

TABLE 2

*Partition of sources of unreliability in photogrammetric measurements*

DIMENSION	MEAN mm photo	$\sigma_{\Delta J_1}$ mm photo	COEF. VAR. $\Delta J_1$	VARIANCE OF DIFFERENCE DUE TO:			PER CENT OF TOTAL DIFFERENCE VARIANCE DUE TO:			STANDARD DEVIATION OF DIFFERENCE IN PER CENT OF MEAN VALUE DUE TO:				
				meas- uring a	posing b	observer c	total a + b + c	a	b	c	$V_a$	$V_b$	$V_c$	$V_{total}$
NTap	13.58	.705	5.20	.0058	.0079	.0019	.0156	37	51	12	.56	.65	.32	.92
NTt	14.47	.755	5.23	.0058	.0256	.0016	.0330	18	78	4	.53	1.11	.28	1.26
TT <sub>1</sub>	26.86	1.42	5.33	.0736	.1211	—	.1929	38	62	0	1.01	1.28	—	1.63
TTnip	29.10	1.84	6.34	.0250	.2048	.0167	.2465	10	83	7	.54	1.56	.44	1.71
TT <sub>2</sub>	25.15	2.19	8.72	.0145	.2543	—	.2686	5	95	0	.48	1.99	—	2.06
TT <sub>3</sub>	29.52	2.02	6.86	.0431	.0747	.0715	.1893	23	39	38	.70	.93	.91	1.47
TB <sub>1</sub>	43.59	2.17	4.98	.0285	.5622	.0061	.5968	5	94	1	.39	1.72	.18	1.77
TB <sub>2</sub>	32.78	1.88	5.24	.0064	.0033	.0010	.0107	60	31	9	.24	.18	.09	.30
TB <sub>3</sub>	40.73	1.72	4.22	.0090	.0694	.0029	.0813	11	85	4	.23	.65	.13	.70
ATU <sub>0</sub>	13.16	1.11	8.52	.0030	.0617	.0067	.0714	4	87	9	.13	1.89	.62	2.03
ATL <sub>1</sub>	10.75	.754	7.01	.0077	.1713	.0033	.1823	4	94	2	.82	3.84	.53	3.97
ATL <sub>3</sub>	7.63	.421	4.48	.0143	.0184	.0000	.0327	44	56	0	1.57	1.78	.00	2.37
LTU <sub>1</sub>	21.92	1.73	7.90	.0191	.0956	.0234	.1381	14	69	17	.63	1.41	.70	1.70
LTU <sub>2</sub>	15.23	1.00	6.59	.0138	.0531	.0649	.1318	11	40	49	.78	1.52	1.67	2.39
LTL <sub>1</sub>	13.44	.811	6.03	.0054	.0118	.0043	.0215	25	55	20	.55	.81	.49	1.09
LTL <sub>2</sub>	6.60	.378	5.72	.0052	.0092	.0009	.0153	34	60	6	1.09	1.45	.45	1.88
FB <sub>2</sub>	16.51	.756	4.58	.0056	.0165	.0109	.0330	17	50	33	.45	.78	.63	1.10
Mean								21	67	12	.60	1.39	.42	1.61
														1.55

$\sigma_c^2$ , the observer variance seen in column 7, is the difference between the measurement of series A by observers J and T minus the measuring error of J (T's measuring error being assumed to be of the same order as J's); that is  $\sigma_{dAJ1}^2 - \sigma_{AJ1}^2 - \sigma_{AJ2}^2$ . In the next three columns, 8, 9 and 10, the percentage of the total variance due to each of the factors  $a$ ,  $b$  and  $c$  is given: thus for NTt most of the source of inaccuracy is attributable to posing difficulties, while for TB<sub>2</sub> measuring itself supplies the greater trouble. This percentage analysis however, does not tell us whether the latter result, for TB<sub>2</sub>, represents very good posing or very bad measuring and the next columns, 11, 12, 13, 14 and 15, report the square root of the variances of columns 5, 6 and 7 expressed as percentages of the mean given in column 2; these figures are therefore similar to the routine coefficient of variation.

These columns 11-15 represent the crucial data of this paper. The last but one gives the differences to be expected when different observers are concerned with these photogrammetric measurements (assuming differences in posing by two different people are small), and the last column when only one observer is concerned, as is often the case even in an extensive research programme. The interpretation of these figures is that 95% of differences to be expected should lie between  $\pm 2v$ , in per cent of the mean. It will be recalled that for repeated measurements of a single person, or the "true" error of measurement, the figures in table 2 should be divided by  $\sqrt{2}$ ; in other words, the limits are about two-thirds of those given. The standard error of  $v$  in this table is about .085  $v$ , so that the figures given are unlikely to lie more than  $\pm .17v$  from their population value.

It will be at once seen that the measuring error  $a$ , is of but slight importance for most dimensions,  $v$ , on the average being only .60. This measuring error includes the error of actual placing of the caliper points at the exact edge of the body on the photograph, and the error, very small, due to the coarseness of the units of measurement used, as discussed most thoroughly by Tildesley ('47). Posing accounts for the

greatest part of the error in most instances, and its figure might be a little increased for different posers, rather than one, though probably most of this error is due to small imperceptible changes in the subject's posture rather than to the large visible differences that the poser can correct. In living anthropometry these two sources of error cannot be distinguished one from another. The observer difference  $c$ , at least in the case of J and T, is not considerable, the average  $v_c$  being .42, of the same order as the measuring error. It is noteworthy that J was not a skilled technician; he had no knowledge of science or biology when engaged, and his total training was an hour or two of instruction followed by the measurement of about 250 pictures and the remeasurement of some of them.

The photogrammetric dimensions named are in most cases exactly those of Sheldon, but a few exceptions must be noted. TTnip is the trunk thickness taken horizontally at the centre of the nipple level, in the lateral view. ATU<sub>o</sub> is so named because our measurement is taken halfway between acromial tip and radiale, which is slightly lower down the arm than Sheldon's. ATL<sub>3</sub> was taken where the curve due to the styloid projection of the radius reached its maximum concavity on the side proximal to the styloid, as opposed to Sheldon's two inches above the maximum projection for his ATL<sub>2</sub> (see fig. 1). Only one measurement proved unsatisfactory in regard to its strict measuring error, and this was ATL<sub>3</sub> with a  $v_c$  of 1.57, nearly equal to its posing error. The observer difference was nil, indicating that so difficult was it to locate this point that J's second readings were just as different from his first ones as T's were from J's. The difficulty lay in locating the styloid bulge, which was clear only in mesomorphic ectomorphs. Possibly Sheldon's ATL<sub>2</sub> may be a little more reliable, but that it is greatly so seems unlikely since he also depends on locating the bulge. Wrist thickness, WT, is considerably more reliable. This is taken in the front view, posed as described, as the minimum diameter of the lower arm perpendicular to the axis of the limb, and is usually but not



invariably at a level where the bulges of the thenar and hypothenar eminences meet the forearm outline. This was measured only on series A and B by T and the  $v_{a+b}$  was 1.74. Despite the difficulty of locating the level for  $ATL_3$ , however, its error  $v_{a+b}$ , is insignificantly larger than the corresponding  $v_{a+b}$  of the living anthropometry wrist circumference; the WT figure is considerably smaller.

Two other  $v_a$  figures are above 1.0; these are  $TT_1$  and  $LTL_2$ . The latter was not found difficult to locate and its relatively high  $v_a$  springs entirely from its low mean value.  $TT_1$ , on the other hand, is the only photogrammetric dimension reported here requiring a two stage measurement: we have taken it by laying a horizontal line as nearly as possible passing through both nipples in the front view, halving the distance between the top of the suprasternal notch (inked in our photos, but fairly easily located without this aid) and this line, laying off this distance vertically from the nipple upwards in the side view, and measuring the horizontal diameter of the chest at the point where this distance ends. (This may bring the level of our  $TT_1$  a little bit below Sheldon's and thus make  $TT_1$  a trifle larger.) This dimension provides a second example of the differences between two successive readings by J being as great as the differences between J's and T's readings. A few other measurements gave some difficulty, though their  $v_a$  figures are reasonably good. There is trouble in deciding where the anterior point of  $TT_3$  should be taken when the superior margin of the pubic hair is ill-defined, i.e., when the so-called "masculine pattern" is present; on such people we have endeavoured to guess where the point would have been were the hair line straight. Though  $v_a$  is only .70, J and T did not judge this point quite the same and the observer difference figure  $v_c$  is .91, the second largest.  $LTU_1$  also presents some difficulty due to the gluteal fold curving very smoothly into the leg in some subjects, making the location of the junction uncertain. The figures are  $v_a$  .63 and  $v_c$  .70, both worse than average, though still quite small.  $LTU_2$  presented a similar difficulty, the anterior point being

hard to define in fat people, and  $LTL_1$  was on occasion made difficult by allowing the calves to touch when posing. In the case of  $LTU_2$  it appeared that J had not entirely followed the measuring instructions and the whole series of measurements were retaken by T. The figures for  $v_a$  are in this one instance T's and the high  $v_c$  should not be taken very seriously—it should diminish considerably when such a misunderstanding is removed.

The posing errors  $v_b$ , are in general very much more important, and the average figure is 1.39. There is again only one really bad figure and this is for  $ATL_1$  as might be expected, since no especial trouble was taken in posing to get the forearm rotated in the lateral view to exactly the same degree on both occasions. Possibly more attention to posing could reduce the figure of 3.84, but it would need a special study before this could be taken for granted. As it is, this forearm measurement is too unreliable for satisfactory use, and is one of the very few dimensions for which living anthropometry is distinctly preferable (see the  $v_{a+b}$  for forearm circumference in table 3). For this reason  $ATL_i$ , arm thickness lower front, defined as the maximum diameter of the forearm taken perpendicular to the axis of the limb in the front view, was measured by T in series A and B. The  $v_{a+b}$  for this diameter was 1.81 (see table 3), considerably less than for  $ATL_1$ , and not too far from forearm circumference. We feel this is probably a better routine measurement than  $ATL_1$ . No other  $v_b$  comes above 2.0:  $TT_2$  is the highest, presumably because variations in the respiratory position alter this measurement more than any other, with TT nipple,  $TT_1$ , and  $TT_3$  following in that order. The figures are small enough to justify the practice of not giving any command to the subject about respiratory position, on the grounds that most people will stop breathing in about the same position, approximately mid-inspiratory, on every occasion. Posing the shoulders as usual presents the next greatest difficulty and  $TB_1$  is 1.72. The observer differences  $v_c$  are mostly trifling, with the exceptions already remarked; this finding confirms

TABLE 3

*Reliability of anthropometric measurements on the living subject*

AUTHOR AND MATERIAL	PRESENT STUDY 65-70 male adults				DAHLBERG ('26) 120-260 adults		DAVENPORT ET AL. ('34) 11 adults	
	Mean	$\sigma_1$	Coeff. var., $V_{a+b}$	$V_{a+b}$	G.D. $V_{a+b}$	S.D. $V_{a+b}$	M.S. $V_{a+b}$	C.B.D. $V_{a+b}$
<i>Dimension</i>	<i>cm</i>	<i>cm</i>						
Stature	172.1	6.62	3.84	.30	.27	.37	.43	.47
Sitting height	90.8	2.55	2.81	.48	..	..	.75	.45
Subischial length	81.1	5.08	6.27	.46	..	..	..	..
Biacromial	38.7	1.69	4.37	1.31	1.16	1.36	1.49	2.00
A.P. chest	20.1	1.52	7.56	1.65	..	..	2.59	3.02
Trans. chest	...	...	...	...	..	..	1.94	1.73
Chest circum.	...	...	...	...	..	..	1.26	1.13
Bicristal	...	...	...	...	.85	.87	2.17	4.10
Circum. neck	38.0	1.59	4.18	1.43	..	..	1.04	1.82
Circum. up. arm	28.5	2.29	8.06	1.76	..	..	1.32	2.43
Circum. forearm	26.9	1.34	4.98	1.37	..	..	1.51	2.34
Circum. wrist	17.7	.99	5.57	2.10	..	..	2.58	2.41
Circum. thigh	53.1	3.40	6.40	.85	..	..	..	..
Circum. calf	36.4	2.20	6.04	1.15	..	..	1.41	1.71
Circum. ankle	21.7	1.14	5.26	1.23	..	..	1.04	.87
	<i>mm</i>	<i>mm</i>						
Subcut. upper arm front	6.4	3.12	48.8	14.10				
Subcut. upper arm back	11.6	5.24	45.2	9.10				
Subcut. thorax back	14.9	4.36	29.3	7.64				
Subcut. suprailiac	10.8	4.19	38.8	7.86				
	<i>cm</i>	<i>cm</i>						
Head length	...	...	...	...	.44	.36	.48	1.04
Head breadth	...	...	...	...	.56	.54	.29	.40
Min. frontal breadth	...	...	...	...	1.75	1.58	.80	2.15
Bizygomatic	...	...	...	...	.75	.60	.61	1.20
Bigonial	...	...	...	...	1.00	1.08	.87	2.03
Nasion-gnathion	...	...	...	...	1.65	1.44	1.82	1.66
Nasion-subnasale	...	...	...	...	..	..	4.42	3.34
Nose breadth	...	...	...	...	..	..	3.34	3.71
Mouth width	...	...	...	...	..	..	3.89	4.31
	<i>mm</i>	<i>mm</i>						
FB <sub>1</sub>	17.94 <sup>1</sup>	.69 <sup>1</sup>	3.86	.86				
FB <sub>2</sub>	16.51 <sup>1</sup>	.76 <sup>1</sup>	4.58	.90				
NH	13.27 <sup>3</sup>	1.07 <sup>3</sup>	8.05	1.88				
NB	9.80 <sup>2</sup>	.68 <sup>2</sup>	6.93	2.26				
MB	12.87 <sup>2</sup>	1.07 <sup>2</sup>	8.30	3.46				
ATL <sub>t</sub>	11.54 <sup>1</sup>	.62 <sup>1</sup>	5.38	1.81				
WT	7.32 <sup>1</sup>	.35 <sup>1</sup>	4.73	1.74				

<sup>1</sup> Multiply by factor 8.33 to obtain living size measurement.<sup>2</sup> Multiply by factor 3.88 to obtain living size measurement.<sup>3</sup> Multiply by factor 3.89 to obtain living size measurement.

that implicit in the similarity of reliability and objectivity coefficients shown in table 1.

*Photogrammetry versus anthropometry of the living.* So much for the internal comparison of the various photogrammetric measurements: the next and more immediately important question is still to be answered. Given the various contributions to the total reliability of these measurements, how does this total compare with the reliability of the corresponding measurement taken directly from the living body?

Table 3 lists the  $v_{a+b}$  (since  $v_a$  and  $v_b$  cannot in this case be measured separately) for the measurements on the living taken by W and T, and, for comparison, those reported by Dahlberg ('26) and by Davenport, Steggerda and Drager ('34). The Dahlberg figures were obtained by dividing the  $\sigma$  reported in the last column of their table 11, p. 199, by the mean, taken as the midpoint of the median frequency for the measurement in question obtained from tables 12 and 13, pages 200 and 201, and multiplied by 100. The Davenport figures are their "quadratic mean differences" divided by the mean,  $\times 100$ , given in columns 3 and 4 of their table 5, p. 274-275. These quadratic mean differences are the same as  $\sigma_d$  if one assumes a zero difference between the mean of the first lot of measurings and the mean of the second, which must be nearly the case. Considerably more weight should be given to Dahlberg's figures, since they examined over 10 times as many people as Davenport: the standard error of their figures is about .05 v, while Davenport's and Steggerda's is .21 v. In Davenport's paper figures for  $\sigma_{meas}$  are also given in table 1, Steggerda having actually made 50 measurements of various dimensions on a single subject. Thus in theory these figures should be just  $\frac{1}{\sqrt{2}}$  times the  $\sigma_d$  given for the same reference. This is approximately so in practice, but the large sampling error of  $\sigma_d$  makes the comparison rather uninformative and the  $\sigma_{meas}$  figures are not reproduced here. At the bottom of table 3 are also given three facial measurements from the  $\times 18$  microfilm enlargements of series A and B taken



by T for comparison with similar facial measurements on the living; and finally the figures for  $FB_1$ ,  $ATL_r$  and WT.

These figures for  $v_{a+b}$  should be compared with those of the last column in table 2. The results are as follows. NTt is better and NTap very much better than circumference of neck.  $TT_1$  and  $TT_{nip}$  are the same as and  $TT_2$  slightly worse than AP chest of this study; all are better than AP chest of Davenport, or, see table 1, of Franzen.  $TT_3$  is without an analogue.  $TB_1$  is slightly worse than biacromial of this study and of Dahlberg's, and the same as Davenport's.  $TB_2$  has no living anthropometry rival and  $TB_3$  is better than bicristal, even of Dahlberg's and much better, see table 1, than bitrochanteric.  $ATU_0$  is approximately the same as upper arm circumference (it should be remembered that here the level at which the measurement was taken remained marked from first to second time in the photograph and in our living study, but not in Davenport's).  $ATL_1$ , discussed above, is very considerably worse and  $ATL_r$  slightly worse than forearm circumference.  $ATL_3$ , also discussed above, is about the same as wrist circumference, but WT is better.  $LTU_1$  is about the same as calf circumference and  $LTL_2$  is slightly worse than ankle circumference. In the face  $FB_1$  and  $FB_2$  are of the same magnitude as bizygomatic and bigonial, and better than minimum frontal diameter. Both photogrammetric nose height and nose breadth have the advantage over their living counterparts and the mouth breadths are approximately the same. In the photo, nose breadth was taken across the point of greatest flare, and mouth breadth between the point of meeting of the two skin-lip margins. Nose height is from the maximal concavity of the bridge to the angle where the under line of the nose meets the upper lip. This last point sometimes gives a little difficulty, and the mouth corners are not always quite unambiguous. Probably more of the error in these measurements is measuring than posing, or so we would guess. But as measuring the face was an afterthought in our experiment, no precautions as to posing the head were taken, and possibly our figures could be improved a bit. In any case, it



seems that not only body measurements, but many of the head and face ones also can be obtained from our photographs.

All in all, we can say that there is little difference between the reliabilities of the photogrammatic measurements and their living body analogues, at least as far as this study goes. Again we see it is the dimension measured and not the method adopted for measuring it which determines the larger part of its reliability.

*Subcutaneous tissue measurements.* Though the measurements of subcutaneous tissue have reliability coefficients of the same general size as the other measurements, age and observer differences figure more prominently. In relation to their small mean, however, the errors are naturally greater and  $v_{a+b}$  is about 6 times as great for the three best as for the circumference measurements. We found in adults that a reading of thorax front tissue cannot always be obtained in fat people; 4 out of our 70 subjects were quite unreadable and a few others somewhat doubtful. Upper arm front is also rather unsatisfactory in that its variability is quite small; if it is used, it should be measured to  $\frac{1}{2}$  mm to meet Tildesley's criteria for estimating the mean and variance of a character in a group. For difference measurements as in following child growth,  $\frac{1}{2}$  mm unit should be used for all these measurements, and our not using this has probably resulted in our difference variances and consequently our  $v_{a+b}$ s being somewhat too high. The reader who considers that fine scaling makes no difference when the measurement is hard to take accurately for other reasons should consult Tildesley's paper. Lastly, it should be stressed that the distribution of subcutaneous tissue measurements in a group of adults is markedly skewed, a subject that needs further examination elsewhere.

*Systematic differences.* A few systematic differences, that is, differences in mean values, occurred both between two series of measurements by J and between series done by J and T. Of the 58 series of J-J differences recorded, the mean values are significantly different at the  $P = .05$  level for 13, whereas chance would predict only 2. The actual difference

between the means is very small, averaging 0.39% of the mean of the measurements concerned. Only one mean difference is over  $\frac{1}{2}\%$ , that for ATU<sub>0</sub> series A and series B. Between observers J and T there were 7 significantly different means out of 17. Three of these are trivial being less than  $\frac{1}{4}\%$ . The other 4 are LTU<sub>1</sub> .53%, ATL<sub>1</sub> .55%, ATL<sub>3</sub> .84% and TT<sub>1</sub> 1.34%. The difficulties in locating these measurements have already been discussed. In the 16 living body measurements only one significant difference was found and this was only  $\frac{1}{4}\%$ .

### *Photographic technique*

*Lighting and type of film.* The administrative advantages of a miniature camera technique have already been pointed out; they must be balanced against the chief disadvantage, that the film image is so small. The reduction ratio at 10 metres lens-subject distance is in fact 74 diameters and points a millimetre apart on the subject photographed are only .013 mm apart on his image. To record such points as different the film must have a very high line resolution, or, as it is commonly called, a very fine grain. This was the reason for our choice of microfilm; but the disadvantage of microfilm is that it is relatively insensitive to light, or slow, and so we needed no less than 8 kw of lamps to illuminate the subject. This amount of light has two main disadvantages; it is rather blinding and warming to the subject, and it is not every place that has that amount of power readily available. The blinding effect matters little with responsible adults, except that changes from a relaxed facial expression tend to occur unless the photographer is careful, but it does make the technique unsuitable for children, and for some hospital work. Consequently, we made tests with Panatomic X to see if the results were greatly inferior or not. Panatomic X needs only 2 to 3 kw of lamps at f/4.5 with the lamps banked as in figure 1, but in one tier: the exposure required is about  $\frac{1}{8}$  of that of microfilm, the American Exposure Indices being respectively 25 and 3, Scheiner numbers 27 and 18.

The purely photographic position is this: that the ultimate accuracy of the technique depends on the line resolution obtained in the emulsion of the film. No amount of enlarging, obviously, will produce detail which is not recorded on the original negative; enlarging is a convenience merely. On microfilm emulsion the Hektor lens at  $f/4.5$  gave a measured resolution of 50 lines/mm on the axis decreasing to 25 lines/mm at the field edge 9 degrees off axis. Corresponding figures for Panatomic X were 30 lines/mm and 15 lines/mm. The reduction at 10 metres being 74 diameters, at the centre of the field points on the object photographed 1.5 mm apart can be clearly distinguished in microfilm, and points 3.0 mm apart in panatomic. This makes it sound as though both methods, and especially the panatomic, are relatively unsatisfactory, since it is generally reckoned that the accuracy of the best head measurements, for example, on the body itself is about 1 mm, that is, that points about 1 mm apart can be distinguished. In fact, however, the measurer of enlargements can in practice do considerably better than the physical analysis implies. Even when strict resolution begins to fail, that is, when the enlargement shows signs of "grain," the caliper points can be placed quite accurately, it seems, in the centre of the somewhat blurred body edge area. The routine  $\times 9$  enlargements of microfilm appear perfectly sharply outlined to the eye when viewed at normal distance, while the  $\times 9$  panatomic are very slightly blurred. But table 4 shows the relative accuracy of measurement on each. It will be recalled that series A and series C were each measured twice by the observer J, and the table shows the results of these measurements. The first column shows the variance of the differences between the two measurements of panatomic ( $C_{12}$ ) minus the same for microfilm ( $A_{12}$ ). These are the figures in square millimeters; in column 2 they are given as a percentage of the variance of posing-plus-microfilm ( $a + b$  in table 1). In the last column the increase in variability due to panatomic is reported as the equivalent of a coefficient of variation, so that these figures are the square roots of the figures of column 1 multiplied by

100 and divided by the mean of the measurement in question. The loss of accuracy due to using panatomic though too large to be due only to chance is really very slight, on the average amounting to only 0.16% of the mean of the measurements and in no case being over 0.8% of the mean. These figures should be compared with those in columns  $v_a$  and  $v_b$  of table 1.

TABLE 4

*Microfile v. Panatomic X accuracy*

MEASUREMENT	INCREASE IN MEASUREMENT VARIANCE DUE TO PANATOMIC ( $C_{12}-A_{12}$ ) $MM^2$	INCREASE DUE TO PANATOMIC IN % OF VARIANCE OF (POSING + MICRO)	INCREASE DUE TO PANATOMIC AS COEFF. OF VARIATION
NTt	.0037	12	0.6
NTap	.0049	36	0.5
TT <sub>1</sub>	.0283	15	0.6
TTnip	.0574	25	0.8
TT <sub>2</sub>	.0061	2	0.3
TT <sub>3</sub>	— .0149	— 15	— 0.4
TB <sub>1</sub>	— .0360	— 6	— 0.4
TB <sub>2</sub>	— .0012	— 13	— 0.1
TB <sub>3</sub>	.0130	17	0.3
ATU <sub>0</sub>	.0083	13	0.7
ATL <sub>1</sub>	.0030	2	0.5
ATL <sub>3</sub>	.0025	8	0.7
LTU <sub>1</sub>	— .0063	— 5	— 0.4
LTU <sub>2</sub>	— .0003	0	— 0.1
LTL <sub>1</sub>	— .0015	— 9	— 0.3
LTL <sub>2</sub>	— .0015	— 10	— 0.6
FB <sub>2</sub>	.0001	1	0.1
Average		4.3%	0.16%

That points closer together than the physical analysis would indicate can in fact be separated by the procedure of judging the middle of the blurred edge is shown by the figures for FB<sub>2</sub>, for example. Two-thirds of repeated measurements of this diameter fall within 0.45% of the mean value, and this works out at an absolute figure of  $\frac{1}{2}$  mm. In 95% of the instances points 1 mm apart can be measured, if not accurately distinguished, then, and this is almost as true for panatomic as it is for microfile.



It is clear that for most purposes panatomic could be used successfully, but it is more tiring to the eye to measure than  $\times 9$  microfile, due to the slight blurring effect: microfile remains preferable where possible. For special studies of the face, where a greater enlargement is convenient, microfile is clearly better: the  $\times 18$  microfile enlargement of head and shoulders has just about the same blurring grain effect as the  $\times 9$  routine panatomic enlargement, due to the resolution being almost double. Measurement errors there should be sensibly the same as for the  $\times 9$  microfile, or at any rate the  $\times 9$  panatomic. We have made no measurements of  $\times 18$  panatomic head and shoulder enlargements, but the blurring effect in this case is large enough to make it less tiring to measure the same diameters on the  $\times 9$  smaller picture. Possibly a  $\times 12$  or  $15$  enlargement would prove the most convenient.

Films and plates of higher resolution than panatomic and higher speed than microfile are of course available for use with other camera set-ups, but these carry their own disadvantages, of enlargement and survey speed. Cold cathode flash discharge lamps of high intensity solve the lighting problem with microfile; though expensive, they are more satisfactory than tungsten lighting for other reasons, too, discussed in the addendum.

*The parallax error.* This difficulty over resolution all arises, of course, because of our long 10 metre subject-lens distance. Were the distance halved (to Sheldon's original one), then the reduction ratio would be halved and the distance between points distinguishable on the negative halved. Furthermore, the 10 metre distance raises formidable administrative problems, necessitating the use of corridors or class laboratories rather than the usual rooms. Why, then, do we not shorten it?

The reason is the parallax error, which must be taken into account in any photogrammetric method. This is to say, those parts of the subject vertically above the centre of the turntable *are* at 10 metres from the camera lens, but the subjects' nipples, say, are not — they are closer. Consequently the



distance between the nipples will be too great if measured from the photograph and multiplied straightforwardly by the factor of  $i_{120}^{1000}$ , the 1 metre at the centre of rotation plane being 120 cm on the  $\times 9$  enlargement. The error from this cause depends on the distance  $d$  between the plane in which the measurement is being taken and the plane through the centre of rotation, and at our 10 metre lens-rotation point distance the error is  $\frac{100d}{1000} \%$ . This is 1% for every 10 cm the dimension measured lies in front of the centre of rotation. For 5 metres it would be 1% for every 5 cm in front of the centre. Were this error constant, it would of course be of no account whatever. But unfortunately such is not the case. The main differential effect of parallax occurs in the side-on photograph, when the arm is measured. The arm is closer to the camera than the 10 metres by about half the bideltoid diameter, the midsagittal plane of the body being approximately in the plane through the centre of rotation. Half the bideltoid diameter varies from about 16 to 25 cm, if only adults of both sexes are considered. If we routinely correct for an arm hung 20 cm closer the camera than the mid-sagittal plane of the body, we shall in extreme instances be in error by  $\pm \frac{1}{2} \%$ , at 10 metres distance. At 5 metres, the error would be 1%, which seems to us scarcely permissible in view of the accuracy of the remainder of the procedure. This particular error could be fairly easily compensated for by always measuring the arm-midsagittal plane distance in the front view photograph, and correcting for it, but if similar rather smaller errors such as those relating to  $LTU_1$ ,  $LTU_2$ ,  $LTL_1$  and  $TB_3$  are all to be considered, the labour becomes excessive. In addition the carriage of the head is not very easily standardised and the distance of  $FB_1$  and  $FB_2$  from the centre of rotation plane must be considered. In circumstances where 1% errors are of no importance, however, a 5 metre distance, using the 9 cm focal length Elmar lens is adequate, and the resolution obtained by it is a shade better than that quoted for the Hektor.

The plate on the turntable against which the subject places his heels is exactly 10 cm behind the centre of rotation, for adults. (Children under 10, 8 cm.) This is a distance of cardinal importance, as it defines the amount by which dimensions such as  $TB_1$  or  $LTL_2$  get closer the camera in the back view than they are in the front view. The figure of 10 cm was chosen to minimise the distance of such dimensions from the centre of rotation, some dimensions then being in front of the centre of rotation plane, and others behind it. In comparing figures from one technique with another, or in the precise repetition of a technique, this figure is even more important than the lens-subject one. To enable the user of the present technique to somatotype subjects anthropometrically from Sheldon's tables (a thing we are particularly concerned to do), we have to know what distances Sheldon used, and these are not given in his book. His anthropometric technique cannot however be duplicated without them. Dr. Dupertuis tells us that the standardising distances work out at 475 cm from the lens node to the centre of rotation of the turntable, and 16 cm from centre of table to heelplate. To convert the Sheldon tables for use with our present technique, the following decreases should be made: 1%  $LTU_2$ ,  $TB_2$ ,  $TB_3$ ; 1½%  $LTU_1$ ; 2%  $TB_1$ ,  $LTL_2$ ; 2½%  $ATU$ ; 3%  $ATL_1$ ,  $LTL_1$ ; 3½%  $ATL_2$ ; and a decrease of 1% for  $FB_1$ ,  $FB_2$  and  $NTt$ . Alternatively, but less conveniently the measurements from the 10 metre-10 cm technique can be increased by these percentages and Sheldon's tables used as they stand. The amount of correction, strictly considered, depends on the subject's size, and the above are figures for our average of subjects; even extreme subjects however depart too little from these averages for their rank in any of Sheldon's tables to be changed. For photogrammetry itself the 10 metre-10 cm technique is, of course, more accurate than the 4.75 metre-16 cm technique.

Since our centre of rotation-heel plate distance is 10 cm when the standard pose (Dupertuis and Tanner, see footnote 5) is used, we routinely correct when converting into actual subject measurements by subtracting 1% for  $TB_1$  and ½% for

LTU<sub>1</sub>, and LTL<sub>2</sub> in the back view, 2% for ATU, 2½% for ATL<sub>1</sub> and 3% for ATL<sub>3</sub> in the side view and 1% for such face breadths as of nose and mouth in the front view. If highly accurate face measurements are to be taken, particular attention must be paid to posing the head at the correct distance from the camera in the front view picture.

*Paper shrinkage.* There are 4 possible sources of photographic distortion in this technique. They are (a) optical distortion due to the camera lens errors; (b) differential distortion of the image on the negative during processing; (c) optical distortion in the enlarging lens and (d) distortion of the printing paper during processing of the enlargements. The first three we have found to be immeasurably small using the equipment detailed, but the enlargement paper is liable to be a problem. The nonshrink waterproof base paper we used is guaranteed to less than .05% shrinkage in two directions at right angles and is therefore entirely adequate for our purpose, and so is bromide foil card or sensitised bromide foil. This special waterproof base paper is now available both in America and Great Britain, but until very recently no manufacturer in England was able to supply us with it, so that at one time we investigated the shrinkage of ordinary bromide paper.<sup>5</sup>

This was done by photographing a grid made by sticking bands of black paper on our original back-screen and making 20 enlargements of the 35 mm negative on waterproof base, 20 on ordinary bromide machine dried, and 20 on ordinary bromide allowed to dry in the air. Twelve measurements were then taken between the inside edges of the grid lines, as detailed in figure 4. All were taken by one observer, T, in this case with a pair of dividers used against a steel scale, since the distances were about 65 mm.

The error may be divided into that which is constant from one piece of paper to another and that which varies from one

<sup>5</sup> While it is true that liquid water cannot penetrate the paper base of the waterproof paper, water vapour can, and in passing from an atmosphere of 12% to one of 90% relative humidity the paper enlarges by ½%, the same figure as for ordinary bromide. This effect is only important when working in humidities below about 40%.

to another. We will consider the latter first; how much enlarging papers processed in these three ways differ from one to another. The usual measure of this, the coefficient of variation of the 20 measurements for each of the 12 dimensions A to L, is given in the first column of table 5. The average is 0.116% for the waterproof base, 0.130% for the air-dried bromide and 0.246% for the machine-dried bromide. In other

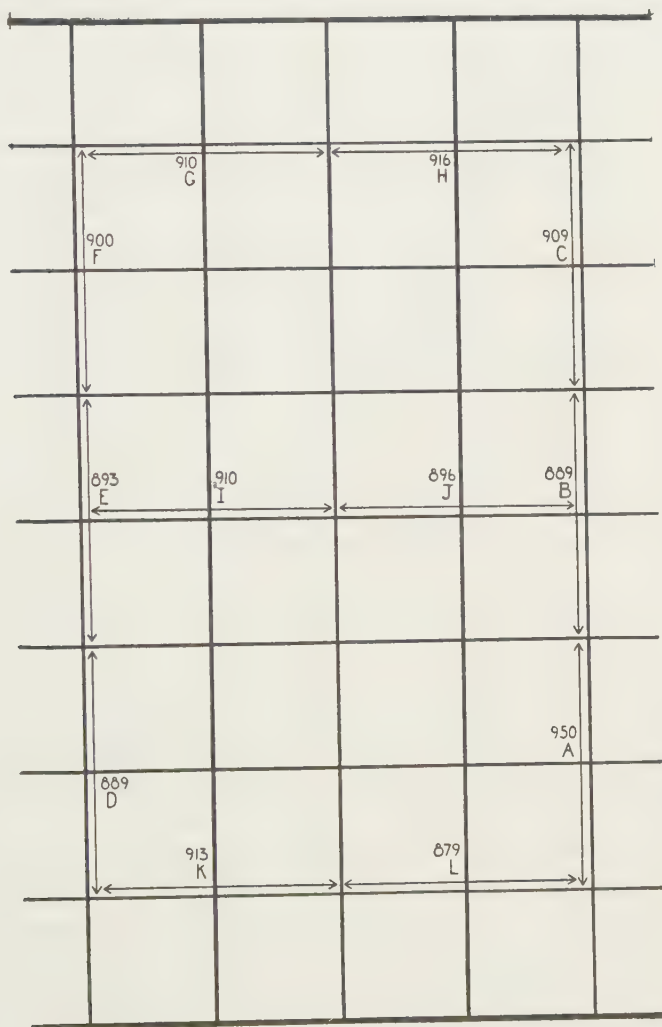


Fig. 4 Paper processing error. For explanation of figures, see text.

words, the variability from paper to paper is nearly as small for air-dried bromide as for waterproof base and in both cases very small compared with our measuring and posing errors discussed above: it need not unduly worry us. The machine drying appears to cause considerable distortion, and these figures immediately put it out of court.

The constant error in processing is slightly more awkward to assess, since unfortunately the setting of the enlarger had

TABLE 5  
*Enlarging paper processing error*

DIMENSION	COEFFICIENT OF VARIATION 20 OBSERVATIONS			RATIO OF AIR-DRIED W.P. BASE Mean of 20 obs.
	W.P. base	Air-dried bromide	Machine- dried bromide	
A	.090	.133	.299	.9950
B	.089	.124	.316	.9889
C	.112	.152	.353	.9909
D	.133	.153	.353	.9889
E	.107	.096	.399	.9893
F	.180	.078	.392	.9900
G	.139	.102	.134	.9910
H	.138	.146	.149	.9916
I	.084	.138	.141	.9910
J	.122	.122	.146	.9896
K	.112	.172	.156	.9913
L	.090	.142	.122	.9879
Grand mean	.116	.130	.246	.9904

to be changed between the three lots of prints and so the three batches are not enlarged to exactly the same degree. Nor was the measurement of the original grid altogether satisfactory so that we are without figures for the true dimensions. However, we may take the waterproof base figures as the true ones, and compare the bromide ones with these. The ratio of air-dried to waterproof base mean is given in the second column of table 5. The grand mean is .9904. The worst deviation from this occurs in dimension A and is of the formidable amount 0.45%. The rest are all considerably less, however,



and the average deviation is 0.13%. The differences between the two types of paper, though repeatable from one sheet to another, seem haphazardly distributed round the points of the compass as can be seen in figure 4 where the numbers refer to this ratio of the means, with the first numeral 9 after the decimal point elided. Distortion certainly has not occurred only in one particular direction: the east-west and north-south averages are almost identical. It can only be, it seems, that this particular lot of 20 sheets of bromide paper had certain strain characteristics running all through the batch. If so, there seems no guarantee that another batch might not be considerably different. Thus while the error arising from using air-dried bromide paper may under some circumstances be relatively unimportant, each batch should certainly be tested separately and the effects assessed. Errors up to  $\frac{1}{2}\%$  of course are not enormous compared to posing errors: and it will be remembered that the perspective error can get that large. Still, such errors all add up, and waterproof base should be used routinely rather than ordinary paper.

We have tried projecting the image onto a screen and taking the measurements that way but found it unsatisfactory. The projected negative images do not show up very well, so that to start with positives have to be made. Positives projected onto a smooth white surface give fairly good definition, but measuring them is awkward, since the measurer's head gets in the way of the light beam. Projection from behind onto a viewing screen, in all other respects the best arrangement, we have found useless simply because we cannot obtain a screen of sufficient resolving power to give a clear picture.

### *Correlation between photogrammetric and living body dimensions*

The correlation between the photographic dimensions measured and their nearest equivalents on the living body is not of vital importance, since we do not have for our aim the

inventing of a set of photographic dimensions which are to duplicate the living body ones, even if this were possible. The test of whether the photographic dimensions are more or less useful than the living body ones depends on such matters as the relative saturation of each in the physique factors of a factor analysis, their ease as guide to the somatotype, and the closeness of their relation to physiological and genetic events. In so far as many of the classical living body measurements were designed to measure the dimensions of a single tissue, bone, they may well have the advantage on the last score;

TABLE 6  
*Correlation of photogrammetric measurements with corresponding measurements on the living*

DIMENSIONS	N = 70	DIMENSIONS	N = 70
AP chest and TT <sub>1</sub>	.756	Circum. upper arm and ATU <sub>0</sub>	.697
AP chest and TTn <sub>ip</sub>	.809	Circum. forearm and ATL <sub>7</sub>	.687
Biacromial and TB <sub>1</sub>	.568	Circum. forearm and ATL <sub>1</sub>	.677
Bideltoïd and TB <sub>1</sub>	.706	Circum. wrist and WT	.752
Bitrochanteric and TB <sub>3</sub>	.951	Circum. wrist and ATL <sub>3</sub>	.808
Circum. neck and NTap	.786	Circum. thigh and LTU <sub>1</sub>	.909
Circum. neck and NTt	.849	Circum. calf and LTL <sub>1</sub>	.929
Circum. neck and NTap and NTt	.875	Circum. ankle and LTL <sub>2</sub>	.817

in so far as the photographic method makes for better assessment of muscle and fat, it has the advantage. But the relations between the two sets of dimensions are not very close.

Table 6 lists the relevant correlation coefficients. In every instance the figure is from the first series of living body measurements and the first series, AJ1, of photogrammetric measurements. Some idea of the standard errors may be obtained from the  $P = .05$  fiducial limits for three of the  $r$ 's. The highest, .951 probably comes from a population whose value lies between .97 and .92; the middle .808, from a population with  $r$  between .88 and .71; the lowest .568 from a population with  $r$  between .71 and .38.

The only relation which is very close is between  $TB_3$  and the bitrochanteric diameter. The coefficient of correlation is .951 and the regression equation

$$TB_3 = 1.03 \text{ Bitroch.} + 2.13$$

where  $TB_3$  is expressed as centimeters on the living body. The standard error of estimate is 0.44 cm which is 1% of the mean value of bitrochanteric.  $TB_3$ , in other words, is an acceptable substitute for bitrochanteric diameter, and probably preferable in that if bitrochanteric aims at measuring fat as well as the other tissues,  $TB_3$  will do this with less distortion of the body, and if bitrochanteric aims at avoiding measuring fat by pressing it away, it often misses the mark. In the present sample, the compression of the body for bitrochanteric must have been just about 1 cm on either side.  $TT_{nip}$  is closer to AP chest than is  $TT_1$ , presumably because it is nearer the level at which AP chest is taken, but the correlation is not very high. Biacromial and  $TB_1$  have the astonishingly low correlation coefficient of .568. Admittedly both are relatively unreliable, but correcting for attenuation due to this cause would only raise the figure to about .60, so the low figure is not explainable this way. The relation of  $TB_1$  with bideltoid diameter is .706, a bit higher, but still low. Biacromial diameter or shoulder girth comes out very largely by itself in factor analytic studies (Burt, '47; Mullen, '40), and it will be interesting to see how  $TB_1$  fares: presumably it lies somewhere between the localised shoulder growth and the more general patterns of growth in girth and growth of muscle. We have tried to get a photographic measure equivalent to biacromial by marking the acromial tips, but as yet we are not satisfied that we have an acceptable substitute: so, in view of its importance, we measure biacromial diameter in addition to taking the photographs.

Whether the circumferences correlate highly with the photographic diameters depends on how much the shape of the part measured varies from person to person. Thus  $ATL_t$

and  $ATU_0$  are lowest, and  $LTL_1$  with calf circumference is highest. The last relation is .929 and the regression equation:

$$LTL_1 = 3.03 \text{ calf circum} - 0.2$$

where  $LTL_1$  is expressed as centimeters on the living body. The standard error of estimate is 0.64 cm which is slightly under 2% of the mean calf circumference. The regression coefficient is not very much less than  $\pi$ , so that the circumference of the calf is almost a circle. Very similar figures, both for  $r$  and the regression coefficient were found by Reynolds ('44) for children, between calf circumference and calf diameter taken in exactly the same position as  $LTL_1$  from an x-ray. The next highest circumference correlation is between  $LTU_1$  and thigh, of .909, then follows circumference of neck and  $NTt$  at .849; then  $LTL_2$  and ankle circumference at .817.

*The routine method for adults.* In conclusion, the present routine we use in measuring adults may be mentioned. We measure stature, sitting height, weight, biacromial diameter, bicondylar diameters of humerus and femur, and subcutaneous tissue of upper arm front and back, thorax back and suprailiac. Head length and breadth and any facial measurements are added on occasion for special purposes. A photograph is taken, and the measurements described in this paper obtained from the subsequent enlargement. If more measurements were to be added they should probably be arm circumference, then leg circumferences.

Three observers, and, if they work rapidly, two, can manage 11 subjects per hour (i.e., one film cassette per hour). The measurements are all done first and the 11 subjects photographed in rapid succession thereafter, unless the subjects' available time precludes this period of waiting. If only stature and weight are measured, the rate is slightly more than doubled and 150 subjects per day can be photographed without undue haste.

#### SUMMARY

An investigation has been carried out to determine whether anthropometric measurements taken from standardised pho-

tographs after the manner of Sheldon are as reliable as measurements taken on the living body.

Seventy subjects had various measurements, including subcutaneous tissue folds, taken twice, and were photographed twice using a Leica camera and microfilm at a subject-lens distance of 10 metres. Enlargements to approximately one-eighth natural size were made and measured, the first series by observer J twice and observer T once, and the second series by observer J once. This design makes it possible to partition the total variability between the two photographs of a single person into that due to measuring error itself, that due to differences in posing on the two occasions, and that due to differences between the two observers. The photographic measurements taken were those of Sheldon, with a few changes and additions. It was found that —

1. Photogrammetric measurements are in general as reliable as measurements taken on the living.

2. In the photographs the posing differences account for two-thirds of the error from one occasion to another, measuring error about one-fifth and observer difference the rest.

3. It is the dimension measured, and not the means adopted for measuring it that in the main determines its reliability.

The paper includes discussions on the measurement and reporting of reliability; on some aspects of the photographic technique, including the use of Panatomic X instead of microfilm, the parallax error and the enlargement paper processing error; and on the correlations, most of which are fairly low, between some photographic measurements and their nearest equivalents on the living.

#### ACKNOWLEDGMENT

We wish most gratefully to thank Mr. W. D. Chesterman for his help and advice with the physical problems involved, and for determining for us the line resolving powers reported. Mr. Farrar, A.R.P.S., made all the enlargements and Mr. J. Giggell did the major number of measurements; our debt to them is obvious. The subjects were volunteers from *H.M.S.*



*Excellent* and to them and to our host there, Commander M. Le Fanu, R.N., and to our recorders, S.B.P.I.'s Baldock and Cague, we wish also to express our thanks and appreciation.

#### ADDENDUM

### AN AIRCRAFT CAMERA TECHNIQUE WITH FLASH OR TUNGSTEN LIGHTING

*Brian Stanford and J. M. Tanner*

The chief disadvantage of the Leica technique is the small size of the negative image; the chief advantage, that a large number of exposures can be made without changing the film. The present arrangement (see fig. 5) does away with the disadvantage, the negative size being  $5'' \times 2\frac{1}{2}''$ , and extends the advantage, giving up to 500 exposures without film change, with automatic winding-on of the film.

*Camera.* The equipment is adapted from a standard  $5'' \times 5''$  aerial mapping camera (British model F24, U.S.A. model K24), fitted with a 20'' focal length lens. The performance of the true 20'' lens, available as government surplus stock in Britain, is markedly superior to the telephoto of the equivalent focal length, and improves steadily as the aperture is decreased from  $f/5.6$  to  $f/16$ . The camera is altered to give a film-shift of  $2\frac{5}{8}''$  and the glass pressure-plate masked accordingly. For use with flash lighting a synchroniser is built into the shutter-assembly to trigger the flash-tube, and the blind aperture is increased to  $2\frac{3}{4}''$ . For tungsten light, the spring-loading of the travelling-slit blind is reduced to give a longer period of travel, permitting instantaneous exposures of the order of  $1/15$  second.

The camera is actuated by remote control through its built-in solenoid release, and film transport is produced automatically by the built-in shutter. This mechanism also moves a Veeder counter attached to the turntable on which the subject stands, so that every negative is automatically numbered. One operator only is required; he poses the subject, steps back to make sure all is adequately aligned, moves a couple of yards to the side and presses a button. This flashes the light, takes the picture, counts the negative and winds on the camera. Alternatively, of course, two operators can work together, if it is thought advisable for the final look at the subject's pose to be taken from 10 metres away.

*Lighting and film.* Lighting can be either by cold cathode flash or by tungsten, but the former has several advantages which offsets

its initial expense. Foremost amongst them is the avoidance of posing a nervous subject or child into the glare of tungsten lights, which blind him, prevent him seeing the camera or even the person who poses him except indistinctly, and often make him feel somewhat uncomfortable and embarrassed. When flash lighting is used the posing is all done in natural daylight or in the artificial light of the room; subjects, even children, do not seem to mind the bright

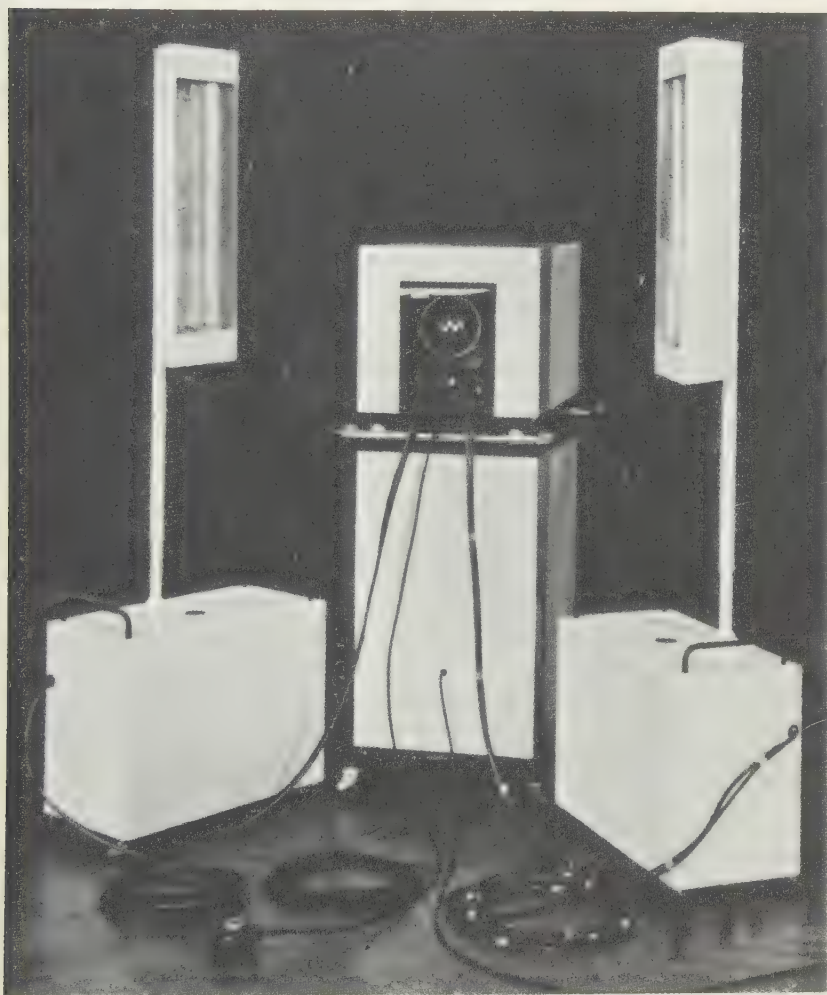


Fig. 5 Photogrammetric camera (adapted aircraft camera) and flash tubes.

flash, and make no objection to it. Flash lighting also gives better modelling of the figure than tungsten, in our experience.

The present flash outfit consists of two 2' tubes, shaped rectangularly so that they fit either side of the corridor our 10 metre distance often constrains us to use. Each is capable of working at 400 joules. This permits an exposure at  $f/16$  on Aeropan Regular film (a panchromatic high-altitude mapping film of Weston rating 64) or at  $f/11$  an Aeropan Contrast (Weston rating 32). It is intended to work on Plus X emulsion (Weston rating 16) with a higher intensity flash for special projects. The problems of grain in the enlargements do not arise however, as with the Leica, since the degree of enlargement is so much less. We develop in DK 20 with continuous agitation at 70°F. for 15 minutes if flash-lighting is used, and for 12 minutes if tungsten.

As at present constructed, the equipment (obtainable from Instrument Developments Limited, 5 Barter Street, London W.C.1.) is housed in a single cabinet for camera and control-gear. From the cabinet lead two cables to the flash (or tungsten) units, and a third to the operator's push-button. The cabinet is sealed except for a front flap which uncovers the lens, and a rear panel which permits changing the magazine. Both panels are locked when the camera is not in use. Linked switches prevent operation unless all is set, and "winking lights" are fitted to give a visual indication of when the flash-tubes are charged. The entire cabinet is positioned on fixed points let into the floor and may be raised off these and wheeled away on castors when not in use.

The turntable is placed by a similar arrangement; it is 6" high, the camera lens centre being 3'4" above the floor. Out of the back of the turntable a light shines on to a white background to eliminate the subject's shadow. The turntable is rotated through a crankshaft by a handle at the operator's waist level some 2' away from the subject. The catch which engages a slot on the table at every 90 degree turn is depressed by a foot-button. There are fixed vertical points exactly 50 cm apart on each side of the subject on the base of the turntable, and fixed horizontal points exactly 1 metre apart on a vertical column at the side; both markers are at the same distance from the camera as the centre of rotation of the turntable, that is, 10" from the node of the lens. A plumb-line is incorporated, the automatic recording counter, a board for the subject's designation, and three 12"  $\times$  10" standard neutral-gray tones of white, mid-gray and black to give a rough estimate of negative contrast on which grade of printing paper may be selected (if in future circumstances a choice becomes possible).

Enlargements exactly similar to those with the Leica technique are made using a continuous roll of waterproof base paper. A second aircraft camera is used as enlarger, and both negative and printing paper are wound on automatically, and the latter automatically processed: this job is done on a commercial basis by the firm from which the cameras are obtained. Alternatively, the camera can be geared to expose one-third of the  $5'' \times 5''$  area at a time, and enlargements made directly of each  $5'' \times 5''$  group: the width of the negative in this arrangement is, however, inconveniently small.

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SURVIVAL OF EARLY INDIAN TYPE IN THE SOUTHWEST.—Some interesting comparisons may be made between the San Simon skulls [San Simon Branch of the San Pedro Stage of the Cochise Culture] and the series of living Yaqui recently studied by Seltzer. The discrepancy between measurements of the living and of the cranium makes it impractical to cite his actual data here; it will suffice to give his comparisons between living Yaqui and other living groups comparable to the skeletal material with which we have compared the San Simon crania. Seltzer characterizes the Yaqui by the smallness of their heads (considerably less than Sioux), moderate height of the head relative to the other dimensions (in this respect between Sioux and Southwestern and Mexican Indians) and, as one of the most outstanding features, the narrowness of the frontal and lowness of the fronto-parietal index. The Yaqui show smaller faces than the San Simon group, though the relative length of the face is more nearly comparable. The slope of the forehead is not striking in the Yaqui. This does not necessarily constitute a discrepancy, however; since in the San Simon group itself forehead vaulting is good in several cases despite a persistent narrowness of dimensions, as if highness of forehead were genetically dominant and breadth recessive. In the frontal diameter, particularly in relation to the parietal breadth, the Yaqui show a likeness to the San Simon group which definitely suggests some survival of the San Simon strain among the Piman tribes.—Alice M. Brues. The San Simon Branch; excavations at Cave Creek and in the San Simon Valley, II. Skeletal material. *Medallion Papers* no. 35, 1946, ix + 26 pp.



# THE CRANIO-FACIAL FRAGMENT OF AUSTRALOPITHECUS PROMETHEUS

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ELEVEN FIGURES

## INTRODUCTION

Following the discovery of the adult, probably female occiput of *Australopithecus prometheus* (Dart, '48a) by Mr. James Kitching in September 1947, the systematic sorting and sieving of the Makapansgat Limeworks dump, initiated by Mr. A. R. Hughes of the Department of Anatomy, yielded in July 1948 an adolescent male mandible (Dart, '48b). Because of this success the Committee of the Bernard Price Foundation for Paleaeontological Research caused the July field work to be resumed during September and October 1948. About 10 tons of fossil-bearing breccia, retrieved from the 600 tons sorted, were transported to Johannesburg during this time; and from it some isolated australopithecine teeth and pelvic fragments have been recovered, as well as the bones of other fossils.

During the process of sorting in the field, Mr. Hughes discovered during September 1948 the isolated and warped right parietal bone of an australopithecine infant overlying a cast of its endocranial surface. He also laid aside another piece of breccia carrying the imprints of teeth. Towards the end of October 1948 Mr. Ben Kitching, who was assisting him, encountered the cranio-facial fragment of an adult australopithecine skull which forms the main subject of this communication (see figs. 1 and 8-11). It was then found by

Mr. Hughes that the breccial fragment exhibiting dental impressions fitted the outer aspect of the cranio-facial fragment perfectly. By casting the interval between the breccia and the broken lateral aspect of the maxilla Mr. B. J. Grobelaar, Laboratory Assistant in the Department of Anatomy, was able to restore the contour of the lost fragment of the broken first premolar, as well as the upward sweep of the broken maxilla, and so to furnish accurate information about

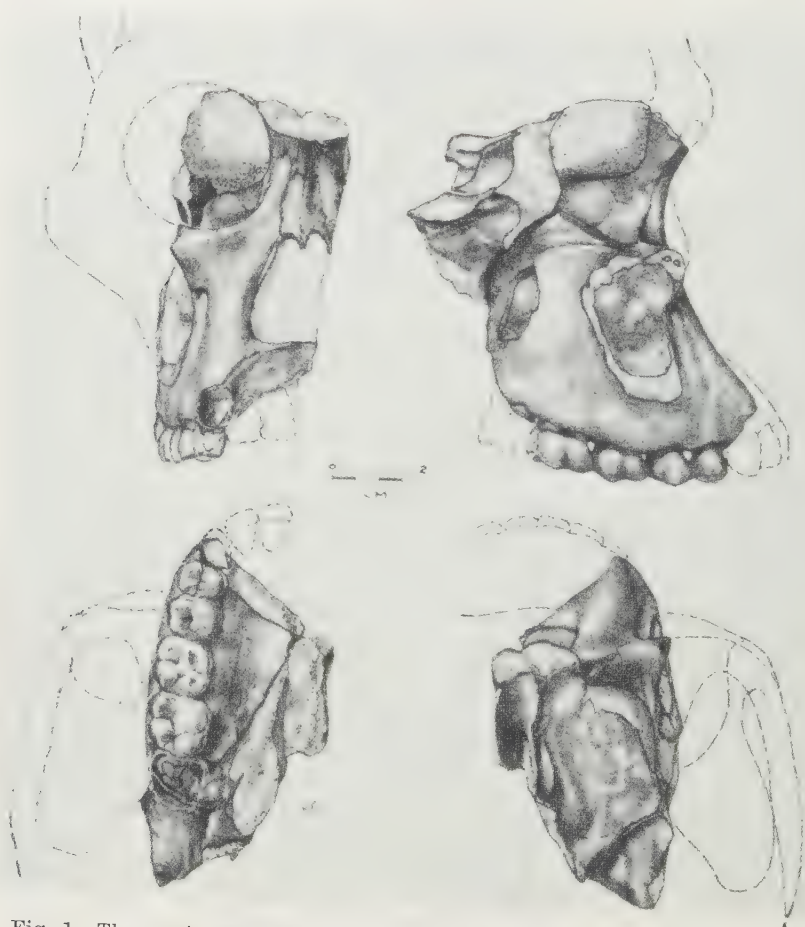


Fig. 1 The cranio-facial fragment of *Australopithecus prometheus* in 4 views, drawn by Mr. J. F. Heim. Normae facialis (upper left), lateralis (upper right), basalis (lower left), and verticalis (lower right).

the form of the upper jaw and the width of the face. After the return to Johannesburg two australopithecine teeth (isolated) were found in the breccia: a worn left lower permanent third molar and a right lower deciduous second molar. These have been illustrated separately (figs. 4 and 5).

The most striking dental feature in which primitive human types, such as *Sinanthropus*, resemble the anthropoids, especially the gorilla and orang, is the much larger size of the teeth in the male sex. The dentition and the state of its attrition show that this cranio-facial fragment belonged to an adult individual, and from the comparative tables of cranial and dental measurements set forth below (see table 2) it appears to have been a female. To judge from its proximity in the dump, it came from the same individual that furnished the occiput mentioned above and upon which the type of *Australopithecus prometheus* was originally based.

For the purpose of description the specimen has been oriented and figured by Mr. J. F. Heim, the artist, upon the vertical plane afforded by mid-line points and the horizontal plane given by the lowest part of the convex occlusal plane of dental attrition.

#### GENERAL DESCRIPTION

##### *Anterior or facial aspect*

The nasal and lacrimal bones are the only bones intact. Running down just lateral to the nasal orifice is the line of suture between the maxilla and premaxilla, which is open in the upper part of its extent as in *A. africanus*. As in *A. africanus* also, the premaxilla does just reach and articulate with the nasal bone, as occurs in the anthropoids. The fact that the suture has remained patent until middle life is significant of the sutural plasticity of the australopithecine skull. The nasal bones of the adult *A. prometheus* have a length (21.4 mm) which is 3.4 mm greater than that of *A. africanus* and 4.6 mm less than that estimated for *Paranthropus*. The width of the two bones together at the nasal

orifice (10 mm) is the same in both specimens. The greatest nasal height (25 mm) and width (22 mm) are considerably greater than those of *A. africanus* (15 × 17 mm) but considerably less than those estimated by Broom for *Paranthropus* (31.5 × 25.5 mm). The inter-infraorbital foraminal width (40 mm) is 17 mm less than in *Paranthropus* but very slightly greater than that in the Taungs juvenile (38.5 mm); while the bimaxillary diameter (60.5 mm) is only a little over a centimeter greater than that of the Taungs child (50 mm).

TABLE 1  
*Comparative facial and palatal measurements*

	A. AFRICANUS (INFANT)	A. PROMETHEUS (FEMALE)	PARANTHROPUS (MALE)
Maxillo-alveolar length (prosthion-avleolon)	43	ca. 69.0	ca. 77.0
Bi-maxillary diameter (opposite M <sup>2</sup> )	50 (opp. M <sup>1</sup> )	61.5	70.0
Premolar — molar length (P <sup>1</sup> —M <sup>2</sup> )	..	43.0	48.0
Inter-infraorbital diameter	38.5	40.0	57.0
Vertical distance between orbital and infraorbital foramen	10.0	13.0	17.0
Vertical distance between orbit and alveolar margin	28.0	44.0	55.0
Length of nasal bones	18.0	21.4	ca. 26.0
Nasal aperture (height)	15.0	25.0	ca. 31.5
Nasal aperture (width)	17.0	22.0	ca. 25.5

Although a great increase occurs in the antero-posterior length of palate during growth, it is remarkable that the distance between a vertical plane passing behind the first permanent molars and a similar plane passing in front of the incisors in *A. africanus* is 44 mm while the corresponding distance in the adult *A. prometheus* could not have been more than 42 mm. Thus in its general facial proportions the adult female *A. prometheus* retains in a remarkable degree those characteristic of the juvenile Taungs specimen. There is the same type of flattened face due to the depressed inter-

orbital region (which is characteristic also of the living Bushman) and a scarcely more marked "canine" ridge of bone running down on either side of the face to ensheathe the sockets of these teeth.

From this anterior aspect the maxilla is seen to be broad and flat, but much less so than in *Paranthropus* and *Plesianthropus*.

The infra-orbital foramen in *A. prometheus* is 13 mm below the inferior margin of the orbit; i.e., only 3 mm lower than *A. africanus* (10 mm) but 4 mm higher than in *Plesianthropus* (17 mm) and 7 mm higher than in *Paranthropus* (20 mm). The total height of the maxilla from the inferior margin of the orbit to the alveolar margin in *A. prometheus* is 44 mm as compared with 28 mm in *A. africanus*, which suggests a considerable (16 mm) vertical lengthening of the face during growth; but the same measurement in *Paranthropus* (55 mm) is 11 mm greater. Thus in facial height also, the promethean female form from Makapansgat assumes a virtually intermediate position between the Taungs child and the Kromdraai adult male. There is clearly an intimate relationship between the specimens from Taungs, Makapansgat and Kromdraai in their general facial proportions; they form a tolerably coherent growth series indicating that the degree of sexual divergence in the australopithecine group as a whole was approximately half of that between the 5 year old child and the adult male (vide also fig. 2).

Unfortunately the violence suffered by the specimen during mining operations removed the lateral half of the first premolar tooth and the canine tooth from its socket (diameter 8.5 mm), and broke away the canine-incisor region of the palate as far posteriorly as the incisive foramen, approximately along the line of maxillo-premaxillary sutural weakness. The horizontal or palatal portion of the maxilla is 3 mm thick at the mid-line, but the oblique plane of fracture anteriorly follows the high arch of the hard palate, and affords from this aspect a picture of its architectural



strength transversely in the inter-canine, frontal plane. Only a small fragment of the zygoma has been retained in the orbital floor.

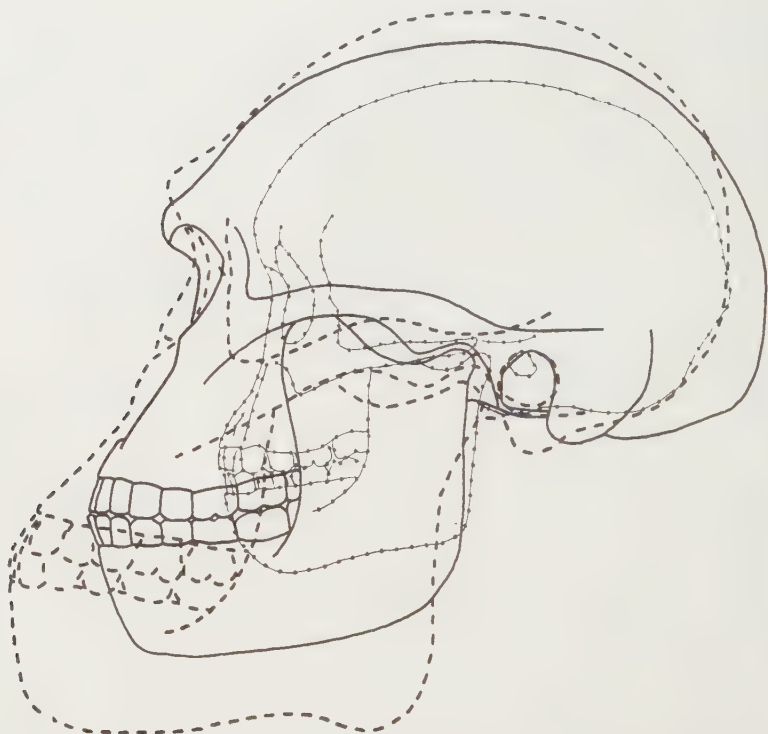


Fig. 2 Superimposition from the lateral aspect and on the Frankfort horizontal of *Australopithecus africanus* (infant) ----, *A. prometheus* (female) ———, and *Paranthropus robustus* (male) - · - · - . One-half natural size.

### *Inferior (or palatal) aspect*

From this point of view the sites and planes of fracture are apparent, as well as the human character of the dental arcade and dimensions of the teeth. (The teeth are described separately below.) Unfortunately, only a triangular fragment of the palatal process has been preserved, but by good fortune it reaches the midline at the incisive foramen. Consequently, despite the loss of the third molar and the pos-

terior part of the palate, which was sheared off with it, there is no doubt about the general proportions. The palate was probably 69 mm long from the posterior margin of the palate to the top of the incisors; while the maxillary diameter opposite the second molar was 61.5 mm, as compared with *Paranthropus* ( $77 \times 70$  mm) for the same measurements. The length of the tooth series (P1-M2) available (43 mm) is 5 mm less than in *Paranthropus* (48 mm).

Relatively to its breadth and length, however, the promethean female palate, by retaining the same depth as that of *Paranthropus* (9 mm) is somewhat deeper than that of other australopithecines. A distinct groove for the greater palatine vessels and nerve creates a slight rugosity of the inferior surface of the maxilla.

#### *Lateral aspect*

Seen from the lateral aspect the specimen reveals the reduced prognathism of this australopithecine type. In this respect it also approximates *Paranthropus*. The base of the zygomatic process of the maxilla has been broken off; but it sprang out of the bone above PM<sup>2</sup> and M<sup>1</sup> as in *Paranthropus*, and not above M<sup>1</sup> and M<sup>2</sup> as in *Plesianthropus*. Consequently in *A. prometheus*, as in *Paranthropus*, the part of the bone behind the process is much greater than the part in front of the process. Correspondingly the maxillary antrum extends further posteriorly.

The maxillary antrum, which has been exposed laterally by the blasting, has also been eroded over a somewhat smaller area posteriorly prior to fossilization, suggesting that the specimen was exposed to the elements for some time before becoming interred. The groove for the infra-orbital vessels and nerve was large: presumably the fleshy parts of the face supplied thereby were massive.

The shattering of the orbital floor and lateral wall made it possible for Mr. Hughes to remove sufficient of the intra-orbital lime deposit to expose the sutural topography of the medial orbital wall. As Broom ('47b) showed for the

female *Plesianthropus*, so also in this female *A. prometheus* the orbital palate of the ethmoid bone has a long articulation with the lacrimal bone, such as is characteristic for man and also occurs in the gibbon and orang. In other words the frontal bones do not approximate the maxillae in the medial wall of the orbit in australopithecine types, as commonly occurs in the chimpanzee and gorilla.

Posterior to the facial fragment there can be seen the shattered sphenoidal bone exposing, below the fracture, part of the lateral pterygoid plate and, above the fracture, the middle cranial fossa with the superior orbital fissure and foramen rotundum in its posteromedial angle. The line of section shows how the forward expansion of the temporo-sphenoidal lobe of the brain has bellied the great wing of the sphenoid anteriorly underneath the sharp margin formed by its antero-superior border and the posterior margin of the small wing of the sphenoid, just lateral and superior to the superior orbital fissure. In these respects also *A. prometheus* corroborates for the australopithecine group the claims set forth by Broom ('47b) relative to *Plesianthropus*.

#### *Superior (or intracranial) aspect*

The anatomical features just described above can be corroborated from this aspect, save that the overlying ala completely excludes the superior orbital fissure from view. Very little of the sphenoidal bone is preserved, but we are fortunate in having an appreciable fragment of the great wing and the lateral part of the sutural relationship of the small with the orbital plate of the frontal bone. This suture, owing to the expansion backwards and increased flattening of the orbital plate, runs laterally almost at right angles to the sagittal plane. The arrangement resembles that in the chimpanzee and it is possible, but improbable, that the two orbital plates of the frontal bone met behind the cribriform plate of the ethmoid bone. The shattering of the skull caused it to fracture towards the cribriform fossa in this region, and the fracture probably followed the medial

half of the fronto-sphenoidal suture. But it is not clear in this case, as it seems to have been in *Plesianthropus*, (see Broom, '47b) that the frontals are widely separated behind the cribriform plate: a younger specimen is required to settle the issue.

For the rest the endocranial topography is very similar to that found in *Plesianthropus*. The olfactory fossa ( $15 \times 7$  mm) is long and narrow as compared with that of a female orang ( $13 \times 10$  mm) in the Department of Anatomy. The ridge of the crista galli, which bisects the fossa longitudinally is 4–5 mm high. The line of the crista galli is continued forwards and upwards, deviating somewhat to the right of the sagittal plane, into a prominent median crest for the attachment of the falx cerebri. There is no foramen caecum; but emerging from the antero-lateral part of the cribriform fossa on either side is a well-marked groove for an anterior meningeal branch of the anterior ethmoidal artery.

The carinated portion of the endocranial cast of the anterior cerebral fossa is at least 15 mm deep and about 30 mm broad. According to Broom's ('47b) diagram, the carinated portion of the *Plesianthropus* endocranial cast constituted a third of the width of the anterior cerebral fossa. If the same relationship held true for *A. prometheus* the total width of the fossa was about 90 mm as compared with 80 mm for *Plesianthropus*. It may be recalled that Schepers ('46) in his table of measurements (op. cit., p. 242) gives the frontal width of the endocranial cast in *Plesianthropus* as not greater than that of the chimpanzee (79 mm), and in *Paranthropus* as 80 mm. His horizontal contour tracings, however, ascribe a maximal frontal width of nearly 80 mm to *Plesianthropus* and approximately 90 mm to *Paranthropus*. The contours seem to accord more closely with the facts brought to light by the more recent discoveries of the entire cranium of *Plesianthropus* and the cranial parts of *A. prometheus*. At any rate the endocranial volume indicated by

this anterior fragment corresponds with that suggested by the occiput (650 cm<sup>3</sup>) previously described.

Text figures 2 and 3 have been drawn by Mr. A. R. Hughes to illustrate the differences and similarities between the 4 known australopithecine types. The reconstruction of *A. prometheus*, which will be published in a later communication,

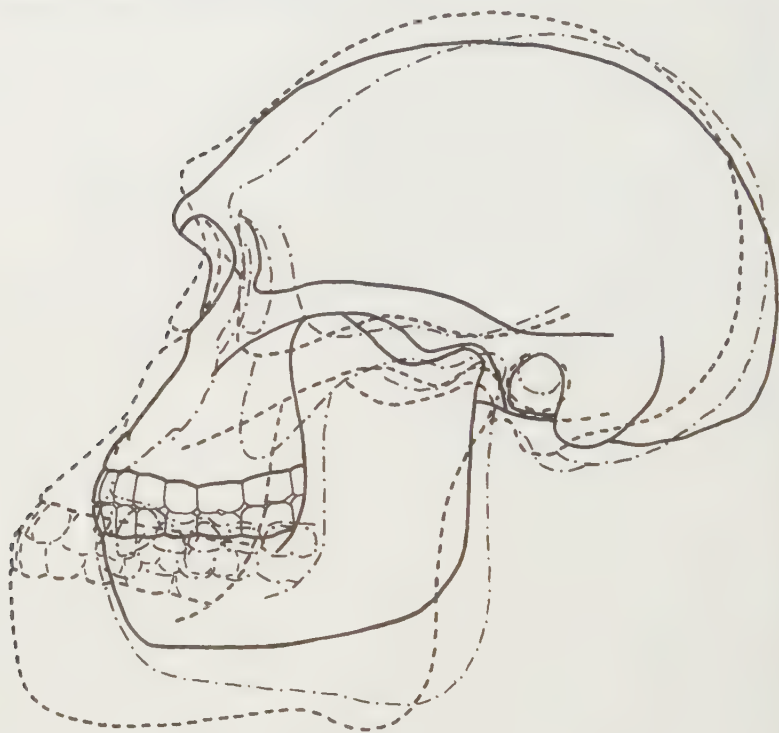


Fig. 3 Superimposition from the lateral aspect and on the Frankfort horizontal of *Australopithecus prometheus* ———, *Plesianthropus* ----, and *Paranthropus* -----. One-half natural size.

is based on the three known fragments (occiput, face and mandible) and comparison with the other adult specimens *Plesianthropus* and *Paranthropus*. It is remarkable how closely the reconstruction of *A. prometheus*, very largely carried out by Mr. B. J. Grobbelaar, corresponds in sagittal contour with *A. africanus*. This figure also shows the general



cranial and facial proportions between a male (*Paranthropus*), a female (*A. prometheus*), and juvenile (*A. africanus*) in the australopithecine group.

The superimposition of the three adult Australopithecinae (fig. 3) illustrates the divergence of *A. prometheus* and *Paranthropus* on the one hand from *Plesianthropus* on the other; and the more human cranio-facial form and proportions in *A. prometheus*.

#### DENTITION OF THE FRAGMENT

The fairly advanced state of wear has obscured the superficial patterns of the occlusal surface in the various teeth preserved (see fig. 10); but the general size and relationships of the cusps, as well as the gross morphology of the teeth, provide sufficient evidence (along with the dentition of the adolescent previously described) of the dental characters of this new australopithecine species.

#### *First upper premolar*

Only the smoothly rounded cusp on the medial half of the crown was preserved; the lateral half had been smashed off during the mining operations. Its width (11.7 mm) was indicated by casting the gap between the fractured surface and the mold of the lateral surface of the teeth left in the adjacent piece of breccia discovered; its antero-posterior length is 8.5 mm. It is therefore within the range of *Sinanthropus*' first upper premolars and smaller ( $8.5 \times 11.7$  mm) than the corresponding tooth of both *Plesianthropus* (♀  $8.7 \times 12.0$  mm; ♂  $9.2 \times 12.3$  mm) and *Paranthropus* (♂  $10.5 \times 13.8$  mm). A female first upper premolar in *Sinanthropus* measured  $8.0 \times 11.6$  mm, while a male tooth measured  $9.2 \times 12.8$  mm. Hence the female *A. prometheus* first upper premolar corresponds very closely with that of *Sinanthropus* in size. The cast shows that the slight grooves situated on the lateral aspect of the tooth and converging slightly towards its apex enclosed a conical buccal swelling similar to that present in

*Sinanthropus*. The split in the tooth occurred along the central furrow; so that on the occlusal aspect there are present only this deep central furrow and slight indications of the medial limbs of the anterior and posterior foveae and an intra-cuspal impression midway between them on the worn cusp. This crown pattern and the measurements of the tooth agree more closely with *Plesianthropus* than *Paranthropus*. The two roots are divergent but there is no indication of the three-rooted condition found well-developed in *Paranthropus* and partially developed in *Plesianthropus*.

### *Second upper premolar*

This tooth with its broad oval shape, and smooth rounded medial cusp and somewhat more pointed lateral cusp, measures  $9.4 \times 12.6$  mm. The largest second upper premolar in a female *Sinanthropus* was  $8.3 \times 12.1$  mm, and in a male  $8.9 \times 12.5$  mm. The corresponding australopithecine measurements are, in *Plesianthropus* ♂,  $9.3 \times 12.8$  mm, and in *Paranthropus* ♂,  $10.5 \times 15.3$  mm. The tooth in *A. prometheus* has distinct anterior and posterior foveae, the anterior fovea showing a strong lateral prolongation and the posterior fovea a marked medial prolongation. Slightly in front of the posterior fovea is a laterally-running bifurcate groove, whose anterior limb reaches the lateral border of the tooth to meet a vertical groove on the lateral or buccal aspect of the tooth and so to separate the small postero-external from the large antero-external cusp. In these respects the valleculae on the tooth reproduce closely the morphology of the corresponding tooth in *Paranthropus* but, apart from the tooth's being a smaller and more square type, the antero-posterior furrow in *A. prometheus* is nearer to the midline than in the teeth of either of the other two types.

This buccal surface also displays a slight groove in the anterior as well as in the posterior half of the tooth, but neither of these vertical grooves on the buccal aspect are more marked than those in *Sinanthropus*.

*First upper molar*

This 4-cusped tooth measures 12.5 mm antero-posteriorly and 12.8 mm across both the anterior and posterior pairs of cusps. It is therefore smaller and more "square" in surface outline than any other australopithecine type. It is virtually identical with the corresponding tooth in *Sinanthropus*. Of this latter, a large female upper first molar measured  $11.1 \times 13.7$  mm, and a male upper first molar  $12.1 \times 13.4$  mm. The corresponding measurements in *A. africanus* are  $12.7 \times 14.6$  mm (the transverse measurement across the anterior pair of cusps being 4 mm less than across the posterior pair); in *Plesianthropus*  $12.5 \times 13.2$  mm and  $12.7 \times 13.7$  mm; in *Paranthropus*  $13.2 \times 15.3$  (anterior cusps) and 13.8 mm (posterior cusps). The occlusal cusp pattern of the first molar is naturally obscured to some extent by the attrition, but agrees closely with that of *A. africanus*, save that the tooth in *A. prometheus* is more nearly "square" and the carabelliform indentation of the antero-medial cusps may have been much deeper. The morphology of the molars in *Paranthropus* is distinguished by the greater breadth of the teeth, especially that across the anterior cusps, and by the contraction of the teeth in the posterior half. It is therefore of interest that *A. prometheus*, which in its facial and to some extent in its premolar morphology approximates more closely *Paranthropus*, simulates *Plesianthropus* in the more nearly "square" morphology of its molars. The principal divergences of the *A. prometheus* molars from those of *Plesianthropus* lie in the facts firstly that the antero-posterior groove is more centrally situated, as in *Sinanthropus*; secondly that the postero-external cusp (relatively enlarged in *Plesianthropus*) is relatively reduced, while the postero-internal cusp (relatively reduced in *Plesianthropus*) is relatively enlarged; and thirdly that the enamel ridge behind the well-marked posterior fovea in *A. prometheus* is smaller than in *Plesianthropus*.

The next effect of these modifications of the molar morphology in *A. prometheus* is that the tooth, being thrown slightly out of square, is somewhat rhomboidal, the diagonals measuring 13.0 mm and 15.0 mm respectively, the antero-lateral-postero-medial diagonal being the greater. In *Sinanthropus* the ordinarily rectangular form of the first and second upper molars is replaced in some cases by a more rhomboidal figure such as appears in *A. prometheus*. The gorilla, orang and chimpanzee also occasionally exhibit the same feature (see, Weidenreich '37, vol 1, p. 64).

### *Second upper molar*

This rhomboidal tendency has the false appearance of being more exaggerated in the larger second upper molar (diagonals 14.6 mm and 16.0 mm). Owing to the relatively small size of the postero-external cusp there is no lateral limb (such as appears in *Plesianthropus*) of the posterior fovea. On the antero-lateral aspect of the antero-lateral cusp and the postero-lateral aspect of the postero-lateral cusps respectively, there is present in both the first and the second upper molars a slight vertical grooving (similar to that on the premolars) representing what remains of the cingulum of anthropoids. For the rest, the morphology of this tooth in *A. prometheus*, as far as it is apparent in the worn tooth, approximates fairly closely that of *Plesianthropus* save that firstly, the antero-external cusp is equal to or larger than the postero-external; secondly there is only the slightest trace of carabelliform indentation on the antero-internal cusp; thirdly the grooves indent deeply both the lingual and buccal aspects of the tooth; and fourthly there is only a post-foveal enamel ridge and no cusplet crenulation upon it.

Its measurements,  $14.0 \times 14.0$  mm (cf. female *Sinanthropus*  $11.1 \times 13.2$  mm), demonstrate the smallness of the tooth relative to those of *Plesianthropus* ( $14.9 \times 15.1$  mm) and *Paranthropus* ( $13.8 \times 16$  mm anterior cusps,  $\times 14.8$  mm, posterior cusps).



## TWO FURTHER ISOLATED TEETH

There were found in the breccia during its development in Johannesburg two further isolated teeth, viz.: an unworn right second lower deciduous molar (probably male) and a worn left third permanent molar (probably female). Because they add appreciably to our knowledge of the type, a description of these isolated teeth is included.

*Second lower deciduous molar (right, male; fig. 4)*

The well-worn second lower deciduous molar of *A. prometheus* was still present in the adolescent mandible which formed the subject of a previous communication to this



Fig. 4 Second lower deciduous molar of *Australopithecus prometheus*, right side. Buccal view (left) and occlusal view (right). Natural size.

journal (Dart, '48b). It was then pointed out that "the 5-cusped second milk molar of *A. prometheus* ( $12.5 \times 10.5$  mm) is somewhat larger than either that of *A. africanus* ( $11.7 \times 10.7$  mm) *Plesianthropus* ( $11.0 \times 9.0$  mm) or *Paranthropus* ( $12.0 \times 9.7$  mm)." The *Plesianthropus* measurements were taken, as I inadvertently omitted to state, from an unpublished drawing kindly loaned to me by Dr. Robert Broom for comparison at that time. I also showed that this worn tooth, while approximately of the same size as *A. africanus*, differed from it in its more nearly square form, the increased size of the antero-internal cusp (metaconid), the decreased size of the postero-internal cusp (entoconid), the enlarged and centrally-placed 5th (or postero-external) cusp (hypoconulid), and the apparent absence of a 6th cuspule.



Figure 4, showing the unworn milk molar ( $12.0 \times 10.4$  mm), corroborates these facts and enables us to see how this remarkable tooth differs from and yet associates itself with the *Paranthropus* deciduous second molar (see Broom and Schepers, '46). The *Paranthropus* tooth is nearly as long but is narrower; it also has a rudimentary 6th cuspule like *A. africanus* and a small subsidiary cusp between the two inner (or lingual) cusps. The *A. prometheus* tooth has no 6th cuspule whatever, but it shows the partial separation from the posterior part of the antero-internal cusp of a subsidiary cusp similar to the isolated subsidiary cusp in *Paranthropus*.

The ridge connecting the two anterior cusps (protoconid and metaconid) in *Paranthropus* is so well developed that the pit-like anterior fovea is virtually completely separated from the remainder of the central antero-posterior furrow while the enamel ridge bounding the fovea anteriorly is thrown into three or four fine crenulated folds. In the unworn *A. prometheus* molar the greater widening out of the tooth anteriorly has resulted in a transversely-running anterior foveal gutter or trigonid basin bounded posteriorly by the ridge connecting the two anterior cusps and anteriorly by a strong enamel ridge crowned with 4 cuspules, of which the most centrally-placed is boldly marked and the most lateral may be regarded as the paraconid. Further, the folding of the enamel on the posterior aspects of the two anterior cusps is so exuberant that what almost amounts to a second transverse ridge and a second transverse gutter between the anterior cusps is formed by their intrusion centrally upon the antero-posteriorly running furrow.

Weidenreich ('37) in his monumental work on the *Sinanthropus* dentition commented (vol. 1, p. 119) on the surprising similarity of the *A. africanus*  $m_2$ , despite its state of wear, to that of *Sinanthropus*, and the close relationship demonstrated thereby between these two forms. His remarks are even more specifically corroborated by this tooth of *A. prometheus*. Another effect of this exuberant enamel folding is to maintain the antero-internal cusp (metaconid) in charac-

teristic broad contact with the intermediate-lateral cusp (hypoconid) at the central (or antero-posterior) furrow and the consequent X-shaped disposition of the antero-posterior and transverse furrows of the tooth reminiscent of the dryopithecine arrangement.

The transverse furrow between the antero-external cusps (protoconid) and intermediate-lateral cusp (hypoconid) and the diagonal furrow between the hypoconid and the posterolateral (or 5th) cusp (mesoconid or hypoconulid) incise the lateral margin of the tooth deeply (see fig. 4, left). As in the permanent molars the transverse furrow is seen to end in a pit, which is continued forward into a cingular furrow bounded below by an appreciable "cingular" ridging of the enamel on the antero-lateral aspect of the tooth. There is

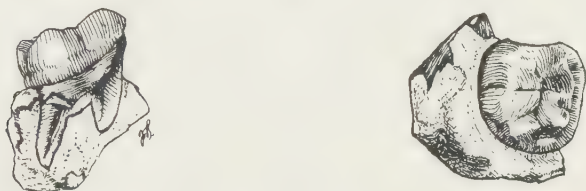


Fig. 5 Third lower permanent molar of *Australopithecus prometheus*, left side. Lingual view (left) and occlusal view (right). Natural size.

therefore little doubt from the exactitude of the comparisons to be drawn between this tooth and the worn second right deciduous molar previously described on the one hand, and the permanent molars in the same adolescent male mandible on the other hand, that we are confronted here with the tooth of a second and younger male *A. prometheus*. It may have belonged to the infant a portion of whose isolated right parietal was found by Mr. Hughes in the same season's work.

#### *Third lower permanent molar (left, female; fig. 5)*

The state of attrition in the specimen, as well as its size ( $14.0 \times 14.0$  mm), suggests that it came from an adult female of the same age as the cranio-facial fragment and probably from the same individual. The corresponding teeth measure

in the *Plesianthropus* male  $16.9 \times 15.2$  mm and in the *Paranthropus* male  $16.5 \times 14.2$  mm. As the second lower molar in the adolescent male *A. prometheus* ( $16.5 \times 15.0$  mm) was smaller than corresponding male *Plesianthropus* ( $17.5 \times 15.5$  mm) and larger than the corresponding male *Paranthropus* ( $15.6 \times 14.6$  mm) molar, it is reasonable to assume that the third lower molar of *A. prometheus* would have been 1.5 to 2.0 mm longer and perhaps 1.0 mm broader than this female third molar.

It has the typical 5-cusped pattern of the *A. prometheus* first and second lower molars, as opposed to the 6-cusped pattern exhibited by the third lower molar of *Plesianthropus*. It therefore approximates more closely the 5-cusped pattern also shown by the *Paranthropus* third lower molar. It retains evidence of the same tendency towards the formation of an extra cuspsule between the two lingual cusps, which we have seen in the deciduous second molar and in the permanent molars of the adolescent previously described: a tendency which was even better displayed also by the second milk molar and the permanent molars of *Paranthropus* and is probably seen in its fully developed form in the 6-cusped molar of *Plesianthropus*. The same sort of accessory cuspsular development between the two main buccal cusps occurred frequently in the molars of *Sinanthropus*, which incidentally display a great variety of cuspal wrinkling.

There is no trace left of an anterior fovea, nor its boundaries, nor of a carabelliform indentation and tubercle (such as occurred on the first and second lower molars of the adolescent type) on the antero-external cusp. The transverse furrow behind the two anterior cusps is just visible: like the diagonal sulcus it indented the buccal aspect of the tooth deeply, but except for the width of the protoconid betrays little evidence of the lateral pitting which probably characterised it. In contradistinction to the first and second lower molars of the adolescent *A. prometheus*, this third

lower molar in the female *A. prometheus* exhibits a pronounced pit-like posterior fovea bounded by a posterior enamel crest, which apparently originally displayed a 6th cuspule.

TABLE 2  
*Comparative diameters of premolar and molar teeth*

		SINAN- THROPUS		A. AFRICANUS		A. PROMETHEUS		PLESIANTHROPUS		PARAN- THROPUS	
		A-P	Trans.	A-P	Trans.	A-P	Trans.	A-P	Trans.	A-P	Trans.
m <sub>2</sub>	♂	12.2	10.1	11.7	10.7	12.0	10.4	11.0	9.0	12.0	9.7
	♀	10.5	9.0	...	...	...	...	...	...	...	...
P <sup>1</sup>	♂	9.2	12.8	...	...	...	...	9.2	12.3	10.5	13.8
	♀	7.4	10.5	...	...	8.5	11.7	8.7	12.0	...	...
P <sub>1</sub>	♂	9.8	10.2	‡ 8.2	9.9	11.5	13.0	13.0	...	10.2	12.8
	♀	7.9	10.2	...	...	...	...	...	...	...	...
P <sup>2</sup>	♂	8.9	12.5	...	...	...	...	9.3	12.8	10.5	15.3
	♀	7.2	10.3	...	...	9.4	12.6	...	...	...	...
P <sub>2</sub>	♂	9.2	11.1	‡ 9.2	11.5	‡ 11.3	12.0	10.4	...	11.8	13.5
	♀	8.7	9.6	...	...	...	...	10.3	12.0	...	...
M <sup>1</sup>	♂	12.1	13.4	12.7	14.6	...	...	‡ 12.5	13.2	13.2	15.3
	♀	10.0	11.7	...	...	12.5	12.8	12.7	13.7	...	...
M <sub>1</sub>	♂	14.1	12.8	14.5	13.3	14.0	14.0	13	...	14.4	13.2
	♀	9.9	10.1	...	...	...	...	...	...	13.5	12.0
M <sup>2</sup>	♂	...	...	...	...	...	...	14.9	15.1	13.8	16.0
	♀	10.2	12.8	...	...	13.0	14.0	‡ 13.7	15.3	...	...
M <sub>2</sub>	♂	12.5	12.7	...	...	16.5	15.0	17.5	15.5	15.6	14.6
	♀	11.9	11.4	...	...	...	...	...	...	...	...
M <sup>3</sup>	♂	...	...	...	...	...	...	‡ 14.3	15.2	14.2	16.0
	♀	8.7	10.4	...	...	...	...	...	...	...	...
M <sub>3</sub>	♂	12.9	12.4	...	...	...	...	16.9	15.2	16.5	14.2
	♀	10.0	10.0	...	...	14.0	14.0	...	...	...	...

#### GENERAL DENTAL CONSIDERATIONS

Table 2, of dental measurements, compares the extreme range of dental variation between the largest male and smallest female *Sinanthropus* teeth (as furnished by Weidenreich, '37) with the measurements now available for Aus-

tralopithecinae teeth. The close anatomical correspondence between the two groups is corroborated mathematically when we find firstly, that the sexual divergence in dental size is scarcely if at all greater in the australopithecine than in the sinanthropine group; secondly, that some australopithecine teeth can be smaller than some corresponding sinanthropine teeth; and thirdly, that the excess in size of the smallest (female) australopithecine teeth over the biggest (male) corresponding sinanthropine teeth is scarcely if at all greater than the difference in size between the biggest (male) and smallest (female) sinanthropine teeth themselves. Actually,

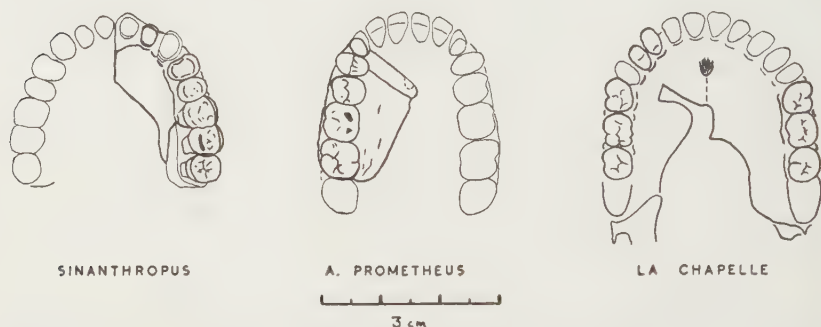


Fig. 6 Palates of *Sinanthropus*, *Australopithecus prometheus*, and Neanderthal Man (La Chapelle), drawn to scale, for comparison.

of course, the australopithecine teeth are larger, some almost rivalling those of the gorilla in size; and because of their size the adult australopithecine palate is a centimeter or more longer than the *Sinanthropus* (or Neanderthal) palate. Meanwhile, owing to the broadening of the human skull, the *Sinanthropus* (or Neanderthal) palate is a centimeter or more wider than the australopithecine palate.

These facts are pictorially expressed in figure 6, where the palate of *A. prometheus* is compared with those of *Sinanthropus* and La Chapelle, as depicted by Campbell ('25). This diagram also shows graphically that in the transformation of the australopithecine palate into the human palate, the premaxillary region (i.e. the part anterior to the incisive



canal) became considerably reduced in length while it increased in width along with the palatal processes of the maxillae themselves. In this process of antero-posterior contraction and lateral widening of the palatal arcade, *Sinanthropus* may be regarded as presenting a phase intermediate between the "Gothic" form of arch in *A. prometheus*, as a representative of the australopithecine group, and the "Roman" arch of Neanderthal Man, as represented by the La Chapelle specimen.

Finally, text figure 7 has been drawn to compare the molar areas of a large male gorilla in the Department of Anatomy with those of the male *Paranthropus*, the female (upper molars) and male (lower molars, except third, which has been taken from the female specimen described above) of *A. prometheus*, and the largest possible sort of Australian dentition (as furnished by the maximal measurements given by Campbell for each tooth in the living aboriginal Australian). It is remarkable how closely the dentition of *A. prometheus* approximates in actual size the extreme limits of this living type of mankind.

When describing the dentition displayed by the adolescent *A. prometheus* mandible, I pointed out the generally more square form of the molar teeth and their closer approximation than other australopithecines in this respect to the human dentition. Their cusp pattern is also intermediate in some respects between those of *Plesianthropus* and *Paranthropus*. But the premolar pattern, especially that of the second premolars, was closer than that of either *Plesianthropus* or *Paranthropus* to the premolar pattern of mankind.

The annectant indications based upon the young male dentition of *A. prometheus* are corroborated by the dentition of this middle-aged female. The permanent upper molar-premolar morphology is closer to that of *Plesianthropus*; the deciduous lower molar and permanent lower molar morphology is intermediate between that of *Plesianthropus* and *Paranthropus* but closer on the whole to that of *Paranthropus*. The premolars are smaller and more humanoid teeth than

those of *Plesianthropus* or *Paranthropus*; the molar teeth also are smaller, more "square" and more humanoid. In point of fact the first upper molar ( $12.0 \times 12.5$  mm) is not larger by as much as a millimeter in either dimension than the first molar teeth of Neanderthal types; and the second upper molar ( $14.0 \times 13.0$  mm) scarcely exceeds Neanderthal types by more than 2 millimeters in either dimension. This range of divergence between the molar teeth of *A. prometheus*

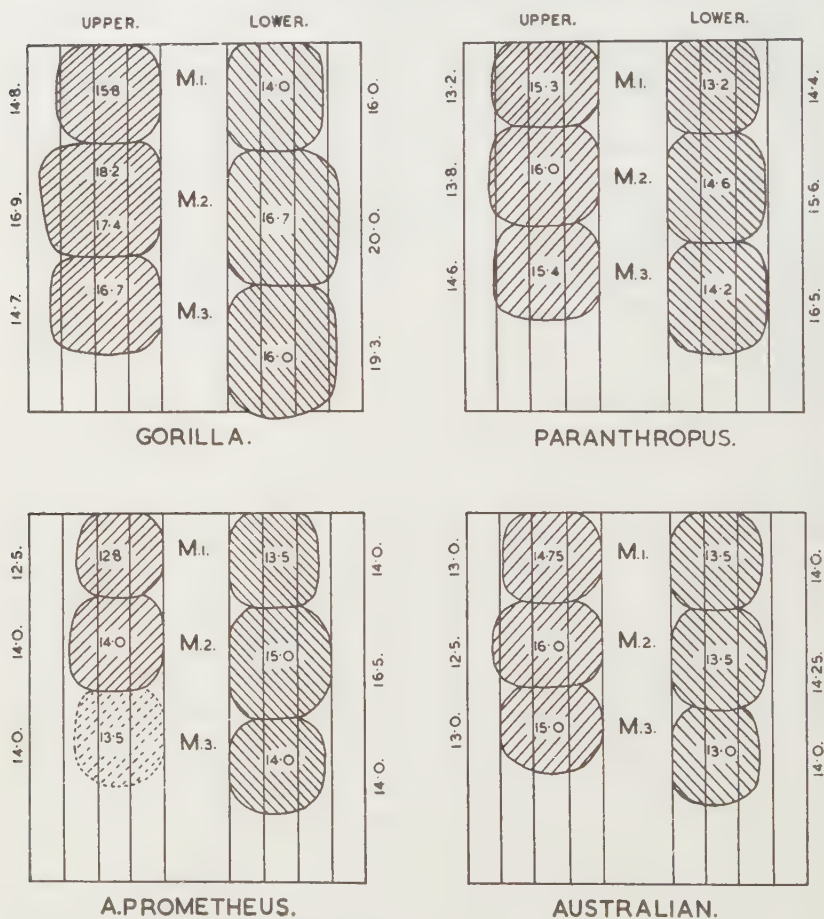


Fig. 7 Diagram to illustrate comparative size of the molar teeth in the gorilla, *Paranthropus*, and *Australopithecus prometheus*; and maximal diameters obtained from Australian aboriginals.

and those of human beings is not greater than that exhibited between *A. prometheus* and other australopithecines.

Of course it is doubtful whether sheer size of teeth has any deep significance. In terms of dental size alone, chimpanzee molars come closer to man than do those even of *A. prometheus*. It is the human pattern of the molar and premolar teeth, as Weidenreich pointed out ('37), that affiliates them with human teeth. Their intermediacy in terms of size as well as pattern allows the teeth in *A. prometheus* to bridge the gap between those of man and the other australopithecines, at the same time as that intermediacy links the other australopithecines to *A. prometheus* in a single closely affiliated group.

#### DISCUSSION

In describing the adult female teeth, features were found that linked *A. prometheus* both to *Plesianthropus* and to *Paranthropus*; but on the whole its dental characters, like the majority of its cranial and facial features, relate *A. prometheus* more closely to *Paranthropus* than to *Plesianthropus*. The brain of *Paranthropus* (650 cm<sup>3</sup>) is very appreciably larger than that of *Plesianthropus* (450 cm<sup>3</sup>); the foramen magnum is farther forward in *Paranthropus* than in *Plesianthropus*. The base of the skull differs correspondingly in the two forms; so *Paranthropus* probably held the head more erectly than *Plesianthropus* (Broom and Schepers, '46).

The occiput of *A. prometheus*, which probably came from the same adult female individual, shows that *A. prometheus* held the head even more erectly than *Paranthropus*, *Pithecanthropus*, or *Sinanthropus*. It also demonstrates that the brain volume was as great as if not greater than that in *Paranthropus*. In these respects the female *A. prometheus* occiput corroborates the evidence of enlarged brain and erectness furnished by the young *A. africanus* (Dart, '48a).

The adolescent male mandible of *A. prometheus* recently described (Dart, '48b), and the cranio-facial fragment (together with the two isolated teeth) described here, furnish

consistent and coherent evidence of this closer affiliation of *A. africanus*, *A. prometheus* and *Paranthropus* with one another than of any of them with the more specialized and less progressive *Plesianthropus*.

#### ACKNOWLEDGMENTS

Many people have collaborated in this work. The fragments would not have been discovered unless Mr. A. R. Hughes had courageously begun the systematic sorting of the dump in July 1948. His and Mr. Schepers Kitching's success in finding the adolescent male mandible caused the Committee of the Bernard Price Foundation for Palaeontological Research to continue the sorting program during September and October. The confidence of the Committee has been fully justified by these further discoveries; and the program of sorting will doubtless be continued; but it is principally to the keen-sightedness of Messrs. Ben Kitching and A. R. Hughes (in the cases of the cranio-facial fragment and deciduous molar) and of Mr. James Kitching (in that of the permanent lower molar) that we are indebted for the specimens described. The skill of Messrs. E. W. Williams and B. J. Grobbelaar is responsible for the reproduction of replicas while Messrs. B. J. Grobbelaar and A. R. Hughes have made the text figures, other than the pictures of the fragment and teeth in their various aspects which, like the previous illustrations of *A. prometheus* remains, are from the accurate and artistic pen of Mr. J. F. Heim. The photographs were taken by my colleague, Dr. Keen. To them and the many other helpers who have not been mentioned by name I express my grateful thanks.

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PLATE 1

EXPLANATION OF FIGURES

Photographs by Dr. Keen of the cranio-facial fragment of *Australopithecus prometheus*. Natural size.

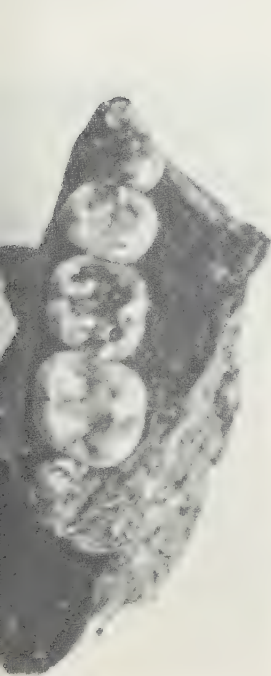
8 Frontal view. 9 Lateral view. 10 Palatal view. 11 Mesial view.



8



9



11



PROFESSOR E. BREITINGER recently wrote as follows in a letter to A. H. Schultz: "I am now with the Institut für Verebungswissenschaft in Frankfurt am Main (Gartenstr. 140). Our old Anthropological Institute in Munich was completely demolished by bombs in the spring of 1944. Only some few of the most valuable objects had been moved in time and thus have been saved. Professor Mollison celebrated his 75th birthday a few months ago. His old pupils visited him for that occasion and found him vigorous and in the best of health."

THE BEGINNING OF ANTHROPOMETRY.—It is in the attempt to establish a standard of measure that is to be found the first effort at regular measurement of parts of the human body. From the most remote periods of which any record remains, the cubit, the foot, the hand, etc., have been the convenient standards, which, possessed by every man, enabled him to adjust his dealings with his fellows, and served to guide him in the construction of his dwellings and his temples.—J. H. Baxter. An outline of the history of anthropometry, or the attempts to ascertain the proportions of the human body. In *Statistics, medical and anthropological, of the Provost-Marshal-General's Bureau*, etc., vol. 1, Washington, 1875, pp. LXII-XXXVII.

HIP SIZE AND RATE OF INCREMENT.—There is not a high degree of relationship between the magnitude of a child's hip width at age 5 and the amount he gains in hip width during the succeeding 2 to 4 years. A succinct means of quantitatively expressing the relationship which does exist is available in the correlation coefficient. The product-moment method of correlation yields coefficients ( $r$ 's) of  $0.36 \pm 0.08$  for hip width at 5 with gain between 5 and 7 and of  $0.31 \pm 0.08$  for hip width at 5 with gain between 5 and 9. While these coefficients denote some degree of positive association between size and gain they are clearly too low to serve as useful media for predicting expected gain in an individual from a record of his size.—Howard V. Meredith and Lois Jean Carl. Individual growth in hip width: a study covering the age period from 5 to 9 years based upon seriatim data for 55 non-pathologic white children. *Child Dev.*, vol. 17, 1946, pp. 157-172.

# RACIAL AND SEXUAL DIFFERENCES IN THE FRONTAL CURVATURE AND ITS RELATION TO METOPISM

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ONE FIGURE

The curvature of the frontal bone is usually expressed by the ratio of the measurements of the frontal subtense to the frontal chord or by the frontal curvature angle (Wilder, '20; Martin, '28). However, both the measurement of the frontal subtense and the frontal curvature angle can only be obtained by the laborious method of drawing a median sagittal craniogram. Recently Newman ('47) took the measurement of the frontal subtense in Peruvian Indian skulls by using the coördinate caliper.

The relation of metopism to frontal curvature has been reported by Papillault (1896). He showed that frontal curvature is greater in skulls with metopism than in those without it. Bryce and Young ('17) and Woo ('41) reported shorter frontal chords in metopic series of skulls than in non-metopic series. Recently Hess ('45) stated that the foreheads of skulls with metopism give the impression of being high, vaulted or prominent.

The present work was undertaken for the purpose of determining the degree of frontal curvature by the use of the coördinate caliper in various racial groups and to determine the relation of frontal curvature to metopism.

## MATERIAL AND METHOD

The skulls studied are of 4 series. The Mongoloid and the American Indian series are from the collections of the U. S. National Museum. The Mongoloid series consists of 66 skulls of male Chinese workmen from Alaska and of 93 male and 70 female skulls of Mongolians from Urga, Outer Mongolia. Collections were made by the late Dr. Aleš Hrdlička. The American Indian series is composed of 48 male and 42 female skulls from Jersey County, Illinois, and of 45 male and 33 female skulls from other counties of Illinois. As the

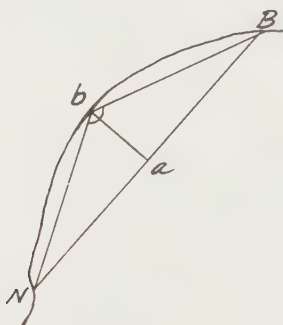


Figure 1

interserial differences are slight and statistically insignificant, they have been combined and designated as the Mongoloid series and the American Indian series of Illinois. In addition, a series of American White and of American Negro skulls in the Terry Anatomical Collection of Washington University were examined. There were 151 males and 34 females in the American White series and 154 males and 83 females in the American Negro series. All the skulls studied are from adults and those with gross pathologic conditions have been excluded. Figure 1 illustrates the points of measurement.

The frontal chord is the straight-line distance from nasion to bregma (N to B).

The frontal subtense is the maximum perpendicular distance from the frontal chord to the frontal curvature (ab).



The frontal index was obtained by dividing the frontal subtense by the frontal chord, multiplied by 100 (frontal index =  $\frac{\text{frontal subtense} \times 100}{\text{frontal chord}}$ ).

An angle was constructed to show the frontal curvature as well. The lengths of NaB, ab and aB were read from the coördinate caliper in mm. (For convenience of reading the scale, the length of aB was taken instead aN.) With these three measurements an angle (frontal curvature angle) showing the frontal curvature can be constructed with ab perpendicular to NB at the point a. Then the degree of the angle was measured with a transparent protractor.

Metopism of the skulls was classified as *complete*, *traces* or *none* (Hooton, '46).

#### RESULTS AND DISCUSSION

The frontal measurements and indices are presented in table 1 according to race, sex and degree of metopism. In the American Indian series no metopism was found in any of the adult skulls. The Mongoloids and the American Whites have almost the same percentage of complete metopism (9.17% in the Mongoloids and 9.19% in the American Whites). Only 1.27% of complete metopism was found in the American Negroes. However, the Mongoloids have the highest percentage of traces of metopism (11.54%), the American Negroes, the next (7.69%) and the American Whites, the least (2.40%). The percentages of complete metopism in these different series generally agree with the data reported by other authors (Martin, '28) excepting that the Mongoloids in the present study show a higher incidence. Recently, T. L. Woo ('41) also reported a high percentage (13.7%) of complete metopism in a modern Chinese series.

Racial differences of the frontal measurements and indices for different series are given in table 2. The order of listing of the series is such that any two adjacent series have less difference than any two other series. For example, the difference in the frontal curvature angle between the American

TABLE 1

*Measurements and indices of the frontal curvature according to race, sex and degree of metopism*

SERIES	SEX	METOPIISM	NO.	FRONTAL CURVATURE ANGLE			FRONTAL CHORD			FRONTAL SUBTENSE			FRONTAL INDEX		
				Range	Mean	S.D.	Range	Mean	S.D.	Range	Mean	S.D.	Range	Mean	S.D.
American Indian	M	None	93	126-145	134.6 ± .27	3.85	104-123	113.20 ± .28	4.02	18-30	23.83 ± .18	2.62	16-26	21.03 ± .14	2.07
	F	None	75	124-145	131.5 ± .31	3.96	101-125	109.52 ± .31	3.98	17-32	24.75 ± .21	2.70	16-27	22.51 ± .17	2.17
Mongoloid	M	Complete Traces None	15 8 136	116-134 128-139 121-138	126.3 ± .59 130.7 131.3 ± .20	3.27 3.45	104-112 105-124 103-127	108.57 ± .38 112.50 113.13 ± .26	2.19 4.48	23-34 20-30 22-33	27.50 ± .42 26.06 25.94 ± .14	2.44 2.35	21-31 20-25 19-28	25.33 ± .43 23.10 22.86 ± .10	2.49 1.79
Total	(Male)		159	116-139	130.8 ± .20	3.78	103-127	112.67 ± .24	4.58	20-34	26.09 ± .14	2.69	19-31	23.10 ± .11	2.00
Mongoloid	F	Complete Traces None	6 16 48	120-129 124-132 121-139	125.5 128.2 ± .53 130.6 ± .38	3.00 3.86	105-111 101-116 95-121	107.58 108.66 ± .88 108.17 ± .42	5.19 4.34	25-32 23-31 18-33	27.67 26.44 ± .38 25.17 ± .26	2.28 2.69	22-27 19-29	24.36 ± .28 23.23 ± .18	1.69 1.86
Total	(Female)		70	120-139	129.6 ± .31	3.89	95-121	108.23 ± .34	4.21	18-33	25.67 ± .22	2.73	19-29	23.70 ± .16	1.97
American Negro	M	Complete Traces None	2 8 144	125-126 117-133 119-139	125.5 126.8 129.8 ± .21	3.72	106-108 107-129 98-126	106.75 115.00 112.60 ± .29	5.11	27-28 24-37 19-35	27.50 29.19 26.54 ± .15	2.61	25-26 22-31 17-30	25.76 25.28 23.52 ± .12	2.21
Total	(Male)		154	117-139	129.6 ± .22	3.98	98-129	112.65 ± .28	5.23	19-37	26.69 ± .16	2.99	17-31	23.64 ± .12	2.29
American Negro	F	Complete Traces None	1 10 72	126.0 124-134 121-138	127.8 ± .57 128.7 ± .26	2.69 3.29	99.00 100-112 97-123	99.00 106.75 ± .79 108.60 ± .42	3.72 5.25	22-30 21-35	25.50 26.30 ± .54 26.28 ± .21	2.55 2.69	22-27 20-28	24.61 ± .36 24.17 ± .14	1.68 1.82
Total	(Female)		83	121-138	128.6 ± .24	3.26	97-123	108.26 ± .44	5.88	21-35	26.27 ± .19	2.59	20-28	24.24 ± .13	1.71
American White	M	Complete Traces None	17 3 131	122-135 125-128 119-138	126.4 ± .57 126.5 128.8 ± .20	3.40 3.43	95-118 110-118 99-126	110.44 ± .82 114.67 113.32 ± .29	5.00 4.88	23-33 28-30 21-35	28.36 ± .37 29.00 27.25 ± .15	2.24 2.60	21-28 25-26 20-30	25.42 ± .30 25.29 24.05 ± .11	1.82 1.87
Total	(Male)		151	119-138	128.5 ± .19	3.54	95-126	113.02 ± .27	4.96	21-35	27.40 ± .14	2.55	20-30	24.26 ± .10	1.91
American White	F	Traces None	1 33	120.0 122-135	128.3 ± .41	3.51	110.00 96-121	110.00 110.67 ± .65	5.53	21-34	32.00 26.91 ± .32	2.74	21-28	24.32 ± .21	1.94
Total	(Female)		34	120-135	128.1 ± .43	3.73	96-121	110.65 ± .63	5.44	21-34	27.06 ± .33	2.85	21-29	24.46 ± .24	2.10

TABLE 2

*Racial differences in the frontal measurements and indices in different series*

MEASUREMENT OR INDEX	SERIES	MEAN DIFFERENCE	P. E. DIFFERENCE	X P. E. <sup>1</sup>
Frontal curvature angle	American Indian	2.8	.28	10.00
	Mongoloid			
	American Negro	1.2	.23	5.22
	American White	.8	.24	3.33
Frontal chord	American White	1.03	.33	3.12
	American Indian			
	Mongoloid	.25	.30	.83
	American Negro	.20	.33	.61
Frontal subtense	American Indian	1.73	.18	9.61
	Mongoloid			
	American Negro	.57	.17	3.35
	American White	.80	.20	4.00
Frontal index	American Indian	1.60	.15	10.67
	Mongoloid			
	American Negro	.56	.13	4.31
	American White	.45	.13	3.46

<sup>1</sup> In this and in succeeding tables interpretation is as follows: X p.e. > 3, significant; = 2.75-3.00, probably significant; and < 2.75, non-significant.

Indians and the Mongoloids is less than that between the American Indians and the American Negroes or American Whites; likewise, the difference in the frontal curvature angle between the American Negroes and the Mongoloids or American Whites is less than that between the Mongoloids and the American Whites. The difference in the angle is greatest between the American Indians and the American Whites. The mean size of the frontal curvature angle decreases in the groups studied in the following order: American Indians, Mongoloids, American Negroes and American Whites. In other words, the American White series has the greatest frontal curvature and the American Indian series, the smallest. The difference between any two series is statistically significant. As seen in table 2, the difference in the size of the frontal chord between any two of the 4 series is insignificant unless compared with the American White group which has the greatest size of the frontal chord and differs significantly with all the other three series. The difference of the frontal subtense between any two of the 4 series is, however, significant. The American Whites have the largest mean frontal subtense and the American Indians the smallest with the other two series between them. The frontal index has the same size relationship as the subtense in the different series. It can be clearly seen from table 2 that the differences of the frontal curvature angle in the different series are due to the different sizes of the frontal subtense and not to those of the frontal chord except in the American White series where both frontal measurements contribute to the racial character of the frontal curvature angle.

The sexual differences in the frontal measurements and indices in the different series are given in table 3. The difference in the frontal curvature angle between the two sexes is significant in all series except the American White; it is greatest in the American Indian series and smallest in the American Negro series with the Mongoloid series intermediate between them. Thus, it may be seen that females

TABLE 3

*Sexual differences in the frontal measurements and indices in different series*

MEASUREMENT OR INDEX	SERIES	MEAN DIFFERENCE	P.E. DIFFERENCE	X P.E.
Frontal curvature angle	American Indian	3.1	.41	7.56
	Mongoloid	1.2	.37	3.24
	American Negro	1.0	.33	3.03
	American White	.4	.47	.85
Frontal chord	American Indian	3.68	.42	8.76
	Mongoloid	4.44	.42	10.57
	American Negro	4.39	.52	8.44
	American White	2.37	.69	3.43
Frontal subtense	American Indian	.92	.28	3.29
	Mongoloid	.42	.26	1.62
	American Negro	.42	.25	1.68
	American White	.34	.36	.94
Frontal index	American Indian	1.48	.22	6.73
	Mongoloid	.60	.19	3.16
	American Negro	.60	.18	3.33
	American White	.20	.26	.77



generally have greater frontal curvature than males. The sexual differences of the frontal chord are significant in all series. Only the American Indians, however, have a significant sexual difference in the frontal subtense measurement. Thus, the sexual differences in the frontal curvature angle are mainly determined, contrary to the racial differences in this angle, by differences in the length of the frontal chord rather than that of the frontal subtense. The sexual difference in the frontal index is significant in all series except in the American White.

As mentioned above, the American White group has the smallest frontal curvature angle and the American Indian group the largest, and the sexual difference of this angle is greatest in the latter and smallest in the former. In the American White series which has the greatest frontal curvature the sexual difference is so small that it is statistically insignificant. From these observations it may be suggested that in groups showing more marked frontal curvature a smaller sexual difference may be expected.

It is interesting to note here that the Whites, instead of having sloping foreheads, as generally believed, have a greater frontal curvature than any of the other series, and the Mongoloids, instead of having upright foreheads, have a smaller frontal curvature than either the American Whites or the American Negroes. The American Indians have the smallest degree of frontal curvature.

From this study it can be seen that both the frontal curvature angle and the frontal index are expressions of the degree of frontal curvature. However, it is better expressed by the frontal curvature angle than by the frontal index because the former more nearly approaches the curvature and thus gives a more direct and clearer conception of the curvature than does the latter.

In table 4 are given the differences in the frontal measurements and indices of skulls with complete metopic suture and of those without it in different series. Only in the male Mongoloid and the male American White series is there a

sufficient number of cases of complete metopism to make comparisons. As shown in table 1, skulls with complete metopism in both the male Mongoloid and the male American White series have smaller frontal curvature angles than the skulls without it in the same series. Skulls with complete metopism have a shorter frontal chord and a higher frontal subtense and, thus, a greater frontal index than those without a metopic suture. The differences between the frontal

TABLE 4

*Differences in the frontal measurements and indices in skulls with complete metopic suture from those without it, in different series*

MEASUREMENT OR INDEX	SERIES	SEX	MEAN DIFFERENCE	P.E. DIFFERENCE	X P.E.
Frontal curvature angle	Mongoloid	M	+ 5.0	.62	8.06
	American White	M	+ 2.4	.60	4.00
Frontal chord	Mongoloid	M	+ 4.56	.46	9.91
	American White	M	+ 2.88	.87	3.31
Frontal subtense	Mongoloid	M	— 1.56	.44	3.55
	American White	M	— 1.11	.40	2.78
Frontal index	Mongoloid	M	— 2.47	.44	5.61
	American White	M	— 1.37	.32	4.28

measurements and between the indices of the two kinds of skulls (with or without metopism) in both series are statistically either significant or probably significant as seen from table 4. Thus, it may be concluded that the skulls with complete metopism have greater frontal curvature than have those without it.

The differences in the frontal measurements and in the indices between skulls with traces of metopism and those

without it in the female Mongoloid and female American Negro series (viz., those series which comprise a sufficient number of cases for comparisons) are given in table 5. As shown in table 1, the skulls showing traces of metopic suture in both series have a smaller frontal curvature angle, a shorter frontal chord and a higher frontal subtense and, thus, a greater frontal index than have those without it.

TABLE 5

*Differences in the frontal measurements and indices in skulls with traces of metopic suture from those without it, in different series*

MEASUREMENT OR INDEX	SERIES	SEX	MEAN DIFFERENCE	P. E. DIFFERENCE	X P.E.
Frontal curvature angle	Mongoloid	F	+ 2.4	.65	3.69
	American Negro	F	+ .9	.63	1.43
Frontal chord	Mongoloid	F	+ .49	.98	.50
	American Negro	F	+ 1.85	.89	2.08
Frontal subtense	Mongoloid	F	— 1.27	.46	2.76
	American Negro	F	— .02	.58	.03
Frontal index	Mongoloid	F	— 1.13	.33	3.42
	American Negro	F	— .44	.39	1.13

However, these differences with the exception of the frontal chord are statistically significant only in the Mongoloid series, whereas, the differences between all the measurements and indices in the American Negro series are so small that they are insignificant. Thus, although the skulls with traces of metopism generally have a greater frontal curvature than those without it, as shown by the mean values of measurements, yet the differences are significant only in the Mongoloid series.

## SUMMARY

In 4 different racial groups a study of frontal curvature and its relation to metopism has indicated that:

1. The American Whites have the greatest frontal curvature; the American Negroes, next; then the Mongoloids; and the American Indians, the smallest.

2. Racial differences in the frontal curvature are mainly determined by the size of the frontal subtense rather by that of the frontal chord, excepting in the American White series where both measurements contribute to the difference.

3. Females generally have a greater frontal curvature than males, due to a shorter frontal chord and a higher frontal subtense. However, the sexual differences are mainly determined, contrary to the racial differences, by the length of the frontal chord rather than that of the frontal subtense.

4. Racial groups showing greater frontal curvature have smaller sexual difference in the curvature.

5. The frontal curvature angle is a better expression of the frontal curvature than is the frontal index.

6. Skulls with complete metopism have greater frontal curvature than those without it.

7. Skulls with traces of metopism generally have greater curvature in mean values of measurements than those without it, but the differences are not always significant.

## ACKNOWLEDGMENT

The writer wishes to acknowledge the kind permission of Dr. T. D. Stewart to study the Mongoloid and the American Indian skulls in the collections of the U. S. National Museum. Thanks are due to Dr. M. T. Newman for the loan of the coördinate caliper, and to both of them, I am also indebted for helpful suggestions. I am grateful to Dr. Mildred Trotter for help.

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THE DANGER IN PLANNED AND ORGANIZED SCIENCE.—I cannot help saying that I have followed with serious misgivings the increasing trend towards planned and organized science, though realizing its need in certain fields. Formerly, a scientist thought out or encountered a problem and started working on it. As often as not he found something in the course of the work which led him in a new direction. An occasional observation, which most others would have overlooked, led the born researcher into new fields, an unexpected flash of an idea opened new vistas and led to solutions or to more problems. All great ideas and all great discoveries in the realm of pure science have come into existence this way.

But now a man does not work on some subject or problem. He has a "project." A plan has been laid out, even worked out in all detail, a staff has been brought together and each one has been assigned his duty. An organization has approved the plan and furnished the funds; in return it expects progress reports, visible and quick results, and no deviation from the plan agreed upon. Everybody is happy to have a "project," and only Minerva covers her face and sends the owl away to catch mice.—Richard B. Goldschmidt. *Research and Politics*. *Science*, vol. 109, no. 2827, March 4, 1949, pp. 219-227.



# A STUDY OF THE RACIAL ANCESTRY OF THE MISSISSIPPI COLLEGE NEGRO

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ONE FIGURE

## INTRODUCTION

About 20 years ago Melville J. Herskovits published the results of his pioneering work on the racial ancestry of the American Negro. On the basis of a genealogical survey Herskovits concluded that about 22% of the American Negro population was of unmixed African ancestry, while the rest had varying amounts of Indian and Caucasian admixture (see table 1).

TABLE 1

*Racial ancestry of the American Negro: Herskovits' sample*

CLASS	NO. OF INDIVIDUALS	PERCENT OF TOTAL
Unmixed Negro	342	22.0
Negro, mixed with Indian	97	6.3
More Negro than White	384	24.8
More Negro than White with Indian	106	6.9
About the same amount of Negro and White	260	16.7
The same class with Indian mixture	133	8.5
More White than Negro	154	9.3
More White than Negro with Indian	75	5.5
Total	1551	100.0

A study of these figures gave rise to a genealogical survey of a similar nature undertaken in the spring of 1947 on the campus of Tougaloo College (Tougaloo, Mississippi) by a small group of students as a class project in a course in Negro history. We too found that the great majority of the

Tougaloo faculty and student body was of mixed ancestry, but our data showed certain outstanding deviations from those found by Herskovits, as indicated in table 2. (For purposes of comparison with a college group the Howard University sample of Herskovits is also included.)

TABLE 2  
*Comparison of the Herskovits and Tougaloo College samples*

CLASS	HERSKOVITS' TOTAL SAMPLE % of 155 <sup>1</sup>	HERSKOVITS' HOWARD UNIVERSITY SAMPLE % OF 538 <sup>2</sup>	TOUGALOO SAMPLE % OF 200
Unmixed Negro	22.0	20.3	8.0
Negro, mixed with Indian	6.3	6.7	27.0
Negro, mixed with White	50.0	47.1	21.0
Negro, mixed with Indian and White	20.9	25.0	45.0
Total of all classes with Indian ancestry	27.2	32.6	72.0
Total of all classes with White ancestry	70.9	73.0	66.0

<sup>1</sup> See table 1.

<sup>2</sup> Herskovits, '30, p. 179.

As can be seen at a glance there are two points at which the differences between the Herskovits and Tougaloo samples are striking: the lesser incidence of unmixed Negroes, and the greater incidence of Indian ancestry in the Tougaloo sample. The latter is reflected not only in the total incidence of Indian ancestry and in the number showing a simple Indian and Negro mixture, but also in the greater incidence of individuals with an ancestry composed of all three racial groups.

Inasmuch as the majority of individuals in the Herskovits sample resided in the eastern part of the United States a geographical differential was suspected. Acting upon the suggestion of Dr. Herskovits I obtained a larger sampling by extending the survey to 4 other schools in Mississippi, and, for purposes of comparison, to one school in each of the neighboring states of Tennessee and Louisiana. The following schools participated:

*Mississippi*: Alcorn A. & M. College, Alcorn  
Campbell College, Jackson  
Jackson State Teachers College, Jackson  
Southern Christian Institute, Edwards  
Tougaloo College, Tougaloo  
*Louisiana*: Dillard University, New Orleans  
*Tennessee*: LeMoyne College, Memphis

In addition to college students the sample includes a sprinkling of faculty members (all schools), some senior high school students (Campbell College and Southern Christian Institute), and a number of veterans taking vocational courses, but not working for a degree (Alcorn and Campbell Colleges).

#### PROCEDURE

*Introducing the survey.* The first step at each school, once the approval of the administration had been obtained, was to present the survey to the students — ordinarily at a general assembly. In a brief talk I would tell them the basic facts relating to the formation of diverse physical types in the human species, with emphasis upon the role of race mixture in this process; explain why anthropologists are interested in studying the racial composition of the American Negro; indicate the results obtained from the Herskovits study; and explain how it was that I happened to be conducting the survey in that particular school. I also emphasized the voluntary nature of participation in the survey, and stressed the fact that the information (except at Tougaloo) would be given anonymously.

*The interviews.* The second step consisted of the interviews. Those conducted at Tougaloo College in the spring of 1947 were done on an individual basis by me and a select group of students working under my direction. The Tougaloo freshman class of September 1947 and the participants at all the other schools were interviewed on a group basis by means of a questionnaire. The groups so interviewed ordinarily ranged from 30 to 60 people in size. The form of the questionnaire used is shown in figure 1.

Completing the genealogical diagram in the questionnaire involved placing in the appropriate blanks the racial composi-

tion of each ancestor about whom information was known. Four symbols were used: "N" for Negro, "I" for Indian, "W" for White, and "C" for Creole. (The word Creole has various meanings — *e.g.* an individual of French descent; an individual of French and Negro descent — and in perhaps a majority of the cases the participants did not know just

# TOUGALOO COLLEGE HISTORY CLUB

Survey on Ethnic Composition of Mississippi  
College Students and Faculty

Fall Semester, 1947

Name of college \_\_\_\_\_

Your age \_\_\_\_\_

Check one: Faculty \_\_\_\_\_ Student \_\_\_\_\_

Check one: Male \_\_\_\_\_ Female \_\_\_\_\_

County and state of birth \_\_\_\_\_

Present residence \_\_\_\_\_

Genealogical data:

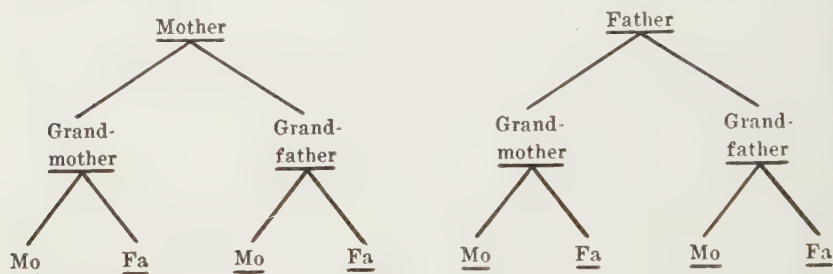


Fig. 1 Sample questionnaire

what Creole meant in their ancestry. Consequently it was given a separate classification.) Other groups such as Chinese, Japanese, or Mexican, were to be written out in full where they appeared. Where necessary the chart could be extended by a participant as far back as he knew his ancestry.

Before filling out the questionnaires the participants were given the opportunity of asking any questions they might have regarding the survey or any relevant anthropological material. They were told again that their participation was purely voluntary, and that they would fill out the question-

naires anonymously. The scientific nature of the survey and the necessity for strict accuracy were emphasized. The participants were clearly directed to indicate only what they were sure of — where they were not sure of a person's ancestry they were to leave the space blank. I then demonstrated how the diagram was to be completed by filling out a black-board model step by step. Questions on the part of the participants were encouraged until all seemed satisfied that they understood the procedure. The students were also encouraged to ask for assistance from either me or their instructor, and a number of them did.

Question can, of course, be raised as to the reliability of the information obtained from a genealogical survey of this nature. In any information passed down by word of mouth from generation to generation inaccuracies are bound to occur because of various psychological factors. It is sometimes said, for example, that Indian ancestry carries a prestige value. This is quite possible, though I did not find any indication of it in my conversations with people while conducting the survey. It is of course impossible to measure the extent of this and any other inaccuracies that may occur in genealogical data obtained by interviews. However, Herskovits has already pointed out that this is obviously the only way to get anything like complete information on the data desired, and like Herskovits I made every effort to eliminate the possibilities of the participants giving false data. In the first place participation was voluntary. In the second place the interviews (except for the first group at Tougaloo where the interviewers were personally known to the participants) were purposely made anonymous. In the third place the necessity for accuracy was stressed. Fourthly I was introduced — usually by the dean of the school — as a teacher at another Negro college, and the administration at each school clearly indicated its support of, and interest in the survey, to the student body. And finally in my talks introducing the survey I was careful to emphasize the widespread occurrence of the phenomenon of race mixture, and to present



the subject in a stimulating fashion. Very few declined to participate. In short the rapport was excellent.

*Making the calculations.* In making the calculations from the data thus secured the following steps were taken:

1. All questionnaires showing inconsistencies in the genealogical data, or indicating no knowledge whatsoever of ancestry were discarded.

2. The questionnaires were then grouped according to the birthplaces of the participants. Two major groups were decided upon: the Mississippi born (1089) and, for purposes of comparison, those born in the nearby states of Tennessee, Louisiana, Arkansas, Texas, Oklahoma, Alabama, Missouri, and Kentucky (390) — referred to as the “nearby states” in tables 3 and 4. The sample of those born outside of this South-Central area was discarded because it was so very small.

3. In classifying the individuals of these two series I followed the same general method as Herskovits. “This,” he writes, “I did as conservatively as I was able to do it. A given individual was classified only on the basis of the actual information given by him. If he stated that, to the best of his knowledge, three grand-parents were unmixed Negro, and if he had no information at all about the 4th grand-parent, then he was classified as unmixed Negro. If he knew of one White grand-parent and of another who was mixed Negro-White, and knew nothing of the other two, he was classified as more White than Negro. In this way 8 classes were formed. . . . Four of these represent differing degrees of Negro blood, and there are 4 corresponding classes for the subjects who were aware of some Indian admixture.” Herskovits, however, did not indicate the “amount of Negro blood, . . . since mixture with Indians is not a thing of the recent past” (Herskovits, '28, pp. 8-9).

I found, however, that for the present sample mixture with Indians appeared to be quite as recent as mixture with Whites, and in any case the great incidence of Indian ancestry necessitated the adoption of a larger classification (as will be noted in the following table), though the same procedure of flexible classification was followed.

TABLE 3  
*Racial ancestry of participants born in Mississippi  
and in nearby States*

CLASS	MISSISSIPPI-BORN		BORN IN NEARBY STATES	
	NUMBER	% OF TOTAL	NUMBER	% OF TOTAL
Unmixed Negro	181	16.6	50	12.8
Mostly Negro with Indian	296	27.2	74	19.0
Mostly Negro with Indian and White	209	19.2	76	19.5
Mostly Negro with White	123	11.3	26	6.7
Total, mostly Negro		57.7		45.2
About one-half Negro with Indian	38	3.5	7	1.8
About one-half Negro with Indian and White	85	7.8	33	8.5
About one-half Negro with White	23	2.1	2	.5
Total, about one-half Negro		13.4		10.8
Less than one-half Negro with Indian	6	.6	1	.25
Less than one-half Negro with Indian and White	92	8.4	37	9.5
Less than one-half Negro with White	3	.3	2	.5
Total, less than one-half Negro		9.3		10.25
Negro with Creole	8	.7	22	5.6
Negro with Creole and Indian	19	1.7	53	13.6
Total, Negro with Creole		2.4		19.2
Negro with Oriental (Chi- nese and Japanese)	2	.2	1	.25
Negro with Oriental and Indian	2	.2	1	.25
Negro with Oriental and White	1	.1	1	.25
Negro, with Oriental, In- dian and White	1	.1	1	.25
Negro with Polynesian and White			1	.25
Negro with Indian and Mex- ican			1	.25
Negro with Indian, Mexican and White			1	.25
Total, with Oriental, Mexican and Polynesian		.6		1.75
Grand total	1089	100.0	390	100.0

## THE DATA

In table 3 are shown the various classes, the number in each class, and the proportion of the total contained in each class for the two series of the present survey: those born in Mississippi, and those born in nearby states. It will be noted that the classifications of Creole and Creole with Indian are given without any proportions of Negro, White and Indian ancestry. This was necessary as relatively few individuals claiming Creole ancestry knew just what it stood for in their particular families, and it would have been hopeless to attempt a percentage classification in such a case. In any event the percentage of Creole ancestry in the Mississippi sample, at least, is negligible.

## DISCUSSION

As indicated earlier the two most striking differences between the Tougaloo sample and the Herskovits sample were the greater incidence of Indian ancestry and the lesser incidence of unmixed ancestry in the former. We shall concentrate our attention upon these two items. Before continuing, however, it must be noted that inasmuch as the majority of those interviewed for this survey were college students the sample is probably not representative of all socio-economic groups in any correct proportions. Consequently if there are any significant differences in racial ancestry among the various socio-economic levels they probably are not properly reflected in the conclusions of this survey. (Herskovits' figures, which were obtained not only at Howard University, but also in a West Virginia community, and from the parents of New York high-school children, are quite likely more representative in this respect.)

Table 4 shows comparative figures of the Herskovits sample and the two series of this survey for certain combined classes. (Creole for this purpose is naturally enough considered as containing White ancestry.)

TABLE 4

*Comparison of Herskovits' sample with samples of present survey for certain combined classes*

CLASS	HERSKOVITS' SAMPLE % OF TOTAL	PRESENT SURVEY	
		MISS.-BORN % OF TOTAL	NEARBY STATES % OF TOTAL
Unmixed Negro	22.0	16.6	12.8
Negro, mixed with Indian	6.3	30.3	21.0
Negro, mixed with White	50.0	14.4	13.3
Negro, mixed with Indian and White	20.9	37.2	51.1
Total of all classes with Indian ancestry	27.2	68.6	73.1
Total of all classes with White ancestry	70.0	51.8	64.9

Turning first to the question of the amount of Indian ancestry it will be noted that both series of this survey support the general trend indicated in the first Tougaloo group, with over two and one-half times the incidence of Indian ancestry in my sample as compared with the Herskovits sample. At the same time the incidence of white ancestry appears to be somewhat lower.

In view of the fact that the Herskovits sample came primarily from the Middle Atlantic and Southeastern States, there apparently exists a pronounced regional difference, especially in the amount of Indian ancestry. In the light of historical fact this is not so very surprising. It must be remembered that by the time African slaves were imported in large numbers into the eastern seaboard states most of the Indians had probably been either killed or forced to move further to the west. In addition most of the intermixture that did occur with Indians of that area occurred so long ago that most memories of it have probably been erased. Such is not the case with the Lower Mississippi Valley where Negro slavery was introduced at a more recent date, and right along with White settlement, before the Indians had been either largely evicted or exterminated. This situation undoubtedly made possible a much higher degree of Indian admixture.

It is interesting to note that Herskovits also found a regional differential in the amount of Indian ancestry (Herskovits, '30, p. 17). Arranging the individuals of his Howard University series in regional groups, he found that 44 individuals or 45% of those from the South Central Division (the same area covered by the present survey, except that Herskovits does not include the state of Missouri) had Indian ancestry, as against 33% for the whole Howard University series (and about 27% for his whole sample). This was second to New England which had 53% claiming Indian ancestry, and was closely followed by the North Central Division which showed 42% claiming Indian ancestry (which is natural, as the lines of migration were pretty generally directly north).

There still remains a discrepancy between the Herskovits figures for the South Central area and those of this survey. It occurred to me that this discrepancy might be a reflection of a time differential. The Herskovits survey at Howard University was taken about 25 years ago — almost a generation. In view of the fact that many individuals of the last generation who had Indian ancestry undoubtedly married individuals without Indian ancestry the total incidence of Indian ancestry had, in all probability, greatly increased. A check on this hypothesis in the case of the Mississippi-born series revealed that of 2142 parents of those interviewed (not quite twice the 1089 who participated as in some cases information was available for only one parent) 939 or 43.1% had Indian ancestry, and that of 757 parents of the series born in nearby states 377 or 49.8% had Indian ancestry, as compared with 45% of the Howard University individuals born in the South-Central division. Naturally the parents of these two series are not precisely comparable with the Howard University series, but the comparison is very suggestive. Consequently the incidence of Indian ancestry for the Negro population as a whole ought to be a good deal higher today than it was at the time of Herskovits' survey; and the re-



gional differential, while present, is not as great as the uncorrected figures seem to indicate.

Turning now to the group with unmixed Negro ancestry it must be noted that the figures given—16.6% for the Mississippi-born series, and 12.8% for the other series are in all probability too high. Not only were some of the participants undoubtedly unaware of the intermixture that had occurred, but the 159 questionnaires which were discarded because of inconsistencies all claimed a mixed ancestry—so that the proportion having unmixed ancestry should be a few points lower, while the other major classifications should be a few points higher.

The differences between the present sample and the Herskovits sample in regard to the incidence of unmixed Negro ancestry, while not as great as indicated by the first Tougaloo group appear sizeable enough. The Herskovits sample of 1551 contained 22% unmixed Negroes, while my Mississippi-born series contained 16.6% and the other group 12.8% unmixed Negroes. Here also I thought it might be valuable to compare the Herskovits sample with the parents of the two series in the present survey, and upon doing so calculated that 738 (out of 2142) or 30.3% of the Mississippi-born series, and 215 (out of 757) or 28.4% of the series born in nearby states were of unmixed ancestry. Again these figures are merely suggestive—the parents of the present sample and the individuals of the Herskovits sample not being exactly comparable. In any event one may expect that there will be almost no unmixed American Negroes within a few generations.

It may be noted also that the Mississippi-born sample showed a sizeably smaller total incidence of White ancestry than the Herskovits sample. This seems less true of the series from nearby states, as is also indicated in the larger incidence of individuals claiming an ancestry composed of all three races, and in the smaller number of individuals with a simple Negro and Indian admixture in this series. It is likely that this differential in incidence of White ancestry between the two series of the present sample is largely due to the presence

of the large number of individuals of Creole ancestry, principally from the Louisiana-born group. That the differential between the total Herskovits series and the two series of the present survey as to incidence of White ancestry is a significant one is shown by a comparison of the parents of the present sample with the individuals of the Herskovits sample. Of the 2142 parents of the Mississippi-born sample for whom information was given, 727 or 33.5% had White ancestry, and of the 757 parents of those born in nearby states 337 or 44.5% showed White ancestry, as compared with 70% for the total Herskovits sample.

That the increased incidence of Indian and White ancestry during the past 25 years is due almost entirely to intermarriage between Negroes and not to any fresh admixture or addition of non-Negro ancestry was shown by a study of the questionnaires. Of the 2142 parents of the Mississippi-born series only 5 were of the unmixed White ancestry, and only 4 were of unmixed Indian ancestry; while of the 757 parents of the nearby states series there were none of unmixed White ancestry, and only one of unmixed Indian ancestry. Carrying this investigation to the grandparents of those interviewed in the present survey it was found that of 3912 individuals for whom data were given in the Mississippi-born series only 85 had unmixed White ancestry, and only 112 had unmixed Indian ancestry; while of the 1410 grandparents for whom information was available in the series born in nearby states only 38 had unmixed White ancestry, and only 26 had unmixed Indian ancestry. In other words substantially less than 20% of those interviewed in the present survey had one or more grandparents of unmixed White or unmixed Indian ancestry. It appears therefore that most of the original White and Indian admixture took place no more recently than three or 4 generations ago. This of course supports the conclusion of various other studies which indicate that intermixture has been on the decline since the Civil War period, and is now practically at an end.

In conclusion then one may say:

1. That there seems to be a significant geographical or regional differential in the incidence of Indian ancestry, with the Lower Mississippi Valley showing a greater incidence than the Middle-Atlantic or Southeastern States.

2. That there also seems to be a significant geographical or regional differential in the incidence of White ancestry, with the Lower Mississippi Valley showing a lesser incidence than the Middle-Atlantic or Southeastern States.

3. That this survey bears out Herskovits' conclusion that the great majority of American Negroes are of mixed ancestry; and that due to the intermarriage of mixed and unmixed Negroes during the past generation the incidence of mixture is undoubtedly significantly greater than it was at the time Herskovits made his survey.

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THE NEWER TEACHING OF ANATOMY.—Anatomy, even naked-eye anatomy is much more than topography. For example, is it not the duty of the anatomist to emphasize the fact that the body is an organism, not just a collection of parts?

Should not the anatomist emphasize the interplay of mind and body, illustrated by Wingate Todd in his radiological studies of the behavior of the alimentary tract and more recently by Wolf and Wolff who showed the effect of a person's state of mind on his gastric mucosa? Has not the anatomist a chance to utter a warning against the danger of over-emphasizing either the psychic or the somatic part of medicine?

Should not the anatomist, by repeated examples, get the student used to the idea of variation—of differences between persons in

respect of every organ and function? This does not mean memorizing variations, but a readiness to make a proper allowance for them when necessary. Of course, if the anatomist shows his students how to make proper allowance for variation in measurements, e.g., of statures and weights, he may be accused of teaching them physical anthropology. Looking at modern physical anthropology, I am inclined to interpret that as praise, rather than blame, for a modern physical anthropologist is essentially a human biologist.

To take another example. If the concept of "constructive medicine" is important, should not the anatomist provide some notions of child development and of the process of aging in adults? Is he not bound to consider the idea of the "normal," and will not this lead him to consider the interplay of heredity and environment, and of the factors, endocrine and others, that regulate and harmonize the parts of the organism? — Donald Mainland. *Anatomy in the changing medical world*. J. Assn. Am. Med. Colleges, November, 1947.

HEREDITARY TRANSMISSION OF DISEASE.—Two classes of people transmit inherited disease to their progeny: (a) those who actually have the disease, and (b) those who appear normal, but whose genetic constitution includes determiners for the disease in question, which determiners for various reasons — environmental factors, dominance relations, etc.—fail to find expression. In the broad sense, "genetic carriers" are those individuals included in the latter group, who may transmit an inherited disease to their progeny without themselves showing *at the time* the commonly accepted findings of the disease. The carriers of the majority of inherited diseases cannot at present be identified clinically, and are known only through the results of a progeny test. However, the transmitters of certain inherited diseases exhibit minor departures from the norm which make it possible to identify them clinically with varying degrees of certainty, depending on the particular disease involved . . .

The ratio of carriers to diseased varies with the frequency of the disease and the manner in which it is inherited . . . Considering the total numbers of diseases in which heredity is an important factor, it is not unlikely that on the average every individual is a carrier for at least one clear-cut, undesirable, pathological condition.—James V. Neel. The clinical detection of the genetic carriers of inherited disease. *Medicine*, vol. 26, no. 2, 1947, pp. 115–153 (with 266 references).

## FRANZ WEIDENREICH, 1873-1948

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Franz Weidenreich died in New York on July 11, 1948 at the age of 75.<sup>1</sup> He was a luckier man than most of us. Though born in the geographical center of the storms to come, he lived through two great wars and survived the deaths of millions of his fellow men. If those wars cost him scientific positions, personal suffering and a life far from his homeland, they led him, fortunately for human paleontology, to Peking and *Sinanthropus*, and finally to the American Museum of Natural History in New York. It was here that he completed his great monograph on the skull of *Sinanthropus* — probably the greatest single achievement of his career.

In the course of a review of that work, I wrote in 1944: "Dr. Weidenreich has been the carrier of a great tradition in a day when narrow specialization has too often impeded the course of science. That there are men in our universities who know his name as a histologist and not as a paleontologist, that anthropologists are often unaware of his contributions in other fields than their own, is both indicative of the breadth of his interests and the increasingly divergent parts of the anatomical sciences."

In the perspective of the years which have since passed, those remarks could, I think, be augmented. It is not my intention to review Dr. Weidenreich's career in detail, but only to remark briefly upon one or two of his intangible but none-

<sup>1</sup> A full account of Dr. Weidenreich's career, written by Dr. W. K. Gregory, has appeared in *American Anthropologist*, 51: 85-90. The bibliography which appears herewith, is unusually extensive and is sure to prove of great value to students of human paleontology.



theless important contributions to our science. Of the fact that his unremitting industry set new standards for the description of human fossils, there can be no doubt. The fertility of his imagination, moreover, has greatly stimulated research in human paleontology. It does not matter in the long run whether Dr. Weidenreich was correct in all his speculations or not — no scientist expects to be. The point is that, in being boldly speculative when the facts warranted, he removed many slavish inhibitions from younger minds, and encouraged independent thinking.

By his constant attention to both old and new discoveries, as well as to known gaps in the record, Dr. Weidenreich succeeded in arousing and keeping the interest of the intelligent public to a remarkable degree. He made human paleontology, in some peculiar manner of his own, as dynamic and attractive as an unfinished novel. It was not that he himself was in any sense a popular writer or a literary man. It was simply that his profuse and stimulating articles, his shining enthusiasm, got through by intermediaries to the press and the general public.

Yet, in the end, it is not the Viking Medalist, the world-renowned anatomist that lingers the most sharply in my memory. Instead it is the recollection of a small man, slightly stooped, and hurrying. From the skull room down that block-long museum corridor to his study, he was always hurrying. There were so many bones, and so little time left in which to understand them . . .

Nevertheless it was not a greedy haste. He loved knowledge, and just as passionately as he pursued it, he loved to impart it. Through circumstances beyond his control, America saw little of him as a teacher, yet Dr. Weidenreich never entirely forgot his earlier devotion to teaching. It would emerge shyly in the presence of any young man who showed a serious interest in the subject, and the desire to learn. More than one of us has listened, fascinated, to an impromptu lecture lasting half the afternoon and, on leaving, carried one's head carefully to keep the newly acquired information from

spilling over before getting it safely home and into notes. His learning was prodigious, and as whole-heartedly given on a street corner as from the lecture rostrum.

He valued knowledge as few men do, but he acquired it only that he might dispense it freely and generously. For this we are grateful to him; because of this our science is richer than it was before.

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**BIOCHEMICAL DIFFERENCES IN GROWTH.**—There is a clear difference between human beings and animals with regard to their respective requirements for methionine [one of the 2 sulphur-containing amino acids], not only for growth, but also for nitrogen balance. Observations were made on rats, on dogs and on human beings. In dogs, the addition of small amounts of methionine was shown to improve the degree of nitrogen retention following the intravenous and subcutaneous injection of a casein hydrolysate. This property was not shared by the addition of any of the other essential amino acids. In rats the same hydrolysate was shown to give a greater average gain in weight with a supplement of methionine. In striking contrast, the observations on human beings were entirely negative . . .

These results are so striking and consistent that they indicate a greater need for sulfur-containing amino acids in animals than in human beings, not only for maintenance, but also for growth. The authors suggest that this fundamental difference may be due to the fact that the animals studied were covered with hair. Since hair contains large amounts of cystine [the other sulfur-containing amino acid], it is reasonable to suppose that the requirement of the rat and the dog for this amino acid or methionine [which can substitute completely for cystine] is considerably greater than that of man. Whether or not this explanation is true, the results emphasize again a basic admonition in biologic work: observations made on animals do not necessarily apply to man.—Editorial. Methionine in human nutrition. *J. Am. Med. Assn.*, vol. 134, 1947, pp. 956-957.

**ATHENIANS A BIOLOGICAL BLEND.**—It is natural to find genetic mixture accompanying the cultural and social blendings involved in the growth of the Athenians. And the discovery that it is a process of biological blending, rather than dominance by any single racial type, which precedes the Classical culture climax shows that genetic mixture is one of the real and probably indispensable little factors which help to produce a great people and which underlie the whole history of civilization.—J. Lawrence Angel. Skeletal material from Attica. *Hesperia* (*J. Am. School Classical Studies Athens*), vol. 14, no. 4, 1945, pp. 279-363 + 20 plates.

## BRIEF COMMUNICATION

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### THE FIRST PELVIC BONES OF AUSTRALOPITHECUS PROMETHEUS: PRELIMINARY NOTE

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#### TWO FIGURES

Another article in this issue deals with a cranio-facial fragment and the dentition of *Australopithecus prometheus*. Concurrently with the discovery of the two isolated teeth described therein, Mr. James Kitching found in another piece of breccia an almost complete left ilium and the major portion of a right ischium of an australopithecine adolescent, probably from the same individual that furnished the adolescent male mandible described by me previously (Am. J. Phys. Anthropol., n.s. vol. 6, no. 4). I am not attempting now to describe this specimen in full; however, on account of its relevance to the crucial question of posture, there are provided herewith two illustrations. Figure 1 is a diagram of these innominate bone elements made by Mr. B. J. Grobbelaar (with the right ischial fragment reversed and co-apted with the left ilium) and compared with left innominate bones of similar age in a Bushman and a chimpanzee respectively, all seen from the lateral aspect. Figure 2 is a photograph of the two parts, showing them also reconstructed, for reference, onto a Bush pelvis.

The innominate bone in *Australopithecus prometheus* is utterly unlike that of the semi-erect chimpanzee, but on the contrary resembles that of the living *Homo sapiens* typified by the Bushman, and not only in its shape and the relative proportions of its constituent parts but even in its actual size. Its broad antero-medially rotated external iliac surface demonstrates the enhanced development of the gluteal musculature and its humanoid disposition relative to the lateral aspect of the pelvis and thigh, which was essential for the maintenance of the erect posture characteristic of mankind.

The discovery of this portion of the pelvis in the grey breccia from Makapansgat near Potgietersrust confirms the numerous other

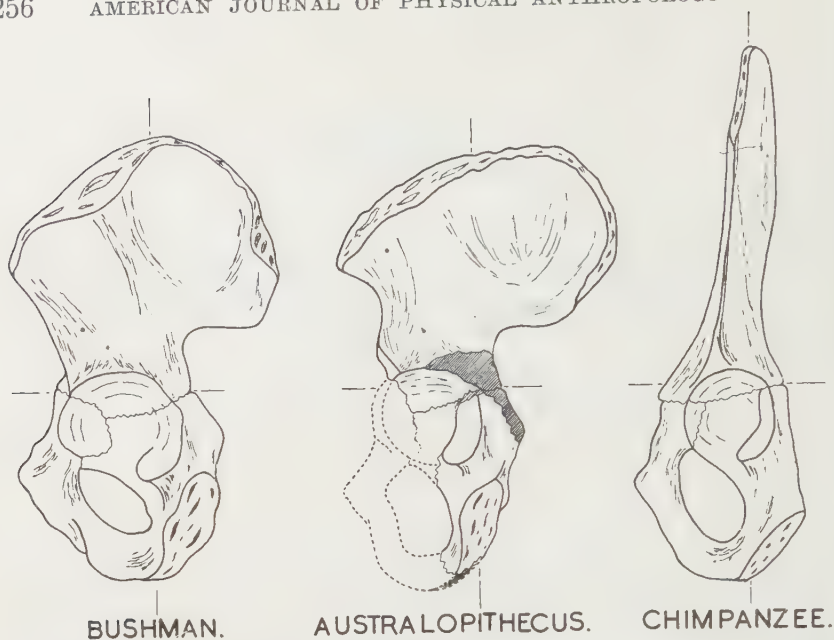


Fig. 1 Comparative view (dioptrographic tracings) from the lateral aspect of the left innominate bone in a Bushman, in *Australopithecus prometheus*, and in a chimpanzee, at approximately the same stages of adolescence (12 years in man). Drawings are to scale. The ischial fragment in *Australopithecus* is of the right side, and has been reversed in the drawings so as to articulate it with the left ilium.



Fig. 2 Fragments of right ischium and left ilium of *Australopithecus prometheus*, together with casts of the same parts reconstructed into a Bushman pelvis of the same age. Norma frontalis, oriented in spino-symphysial plane. Photograph by Dr. Keen.



indications of postural uprightness in the australopithecine group; and simultaneously corroborated the discovery by Broom of an adult innominate bone of similar human character at Sterkfontein near Krugersdorp nearly 200 miles southward in the Transvaal. It further vindicates, by its closer approximation to the human form than the *Plesianthropus* innominate bone from Sterkfontein, the foregoing evidence that *Australopithecus prometheus* walked more erectly than *Plesianthropus* and had a body build and carriage closely comparable with that of the living Bushman.

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#### EDITOR'S NOTE

*Manuscripts of high quality and interest have been offered to the Journal recently at a rate which has threatened not only to delay their publication unduly but also to create a backlog of such material ahead of other incoming papers. In this situation, the Viking Fund has generously provided funds to relieve matters by covering the cost of a number of extra pages for several issues, beyond what the Wistar Institute, which has itself always been most generous in its handling of the Journal, can allow. Once more the Editor and the Association must acknowledge with pleasure the help which the Viking Fund has constantly been giving to physical anthropology. In the long run, a Journal with ample space and broad interest will have to depend on a larger subscription list and the active support of physical and other anthropologists. It is hoped that the present measure will act as a stimulus to help create that interest and support.*



PHYSICAL ANTHROPOLOGY IN INDIA.—The years of the global war saw in India considerable progress in anthropometry and racial biology. The serological investigations that were begun by E. W. E. Macfarlane before the Silver Jubilee Session of the Indian Science Congress, were continued by her and a large mass of data was collected. . . .

In 1941 the Census Commissioner for India initiated a scheme for an anthropological and serological survey for the United Provinces, and this was carried out by Dr. N. Datta-Majumder of the Lucknow University. . . .

The statistical analysis of the blood-groups data showed a close coincidence of the serological findings with the anthropometric, and thus established the claims of serology as a suitable tool for anthropological taxonomy. From the point of view of homogeneity or otherwise among the estimated probability of A genes, the various castes or tribes whose blood was sampled during the U. P. Anthropological Survey could be put into groups, each having higher *p*-values than the preceding, corresponding to the constellations found on the basis of anthropometry . . . N. Datta-Majumder. *Anthropology during the way*. VI. India. *Am. Anthropol.*, n.s. vol. 49, 1947, pp. 159-164.

POPULATION GROWTH IN THE PACIFIC REGION.—My conclusion . . . is that most of the countries of South and East Asia have already entered upon a period of population expansion quite similar to that which took place in the Western World after 1800 and that a similar growth in those lands for which data are unsatisfactory only awaits the establishment of internal peace, the development of a moderately effective health service, the improvement of transportation, and the expansion of agriculture through irrigation and better farm practice, all of which these lands hope for in the near future. This growth of population in South and East Asia, which contain all but a small part of the population of the Pacific Region, coupled with the fact that in much of the West the birth rate is no longer high enough to maintain present numbers (to say nothing of providing colonists for tropical areas), means that a large part of the population growth of the world during the next few decades will almost certainly take place in this region.—Warren Thompson. *Population and peace in the Pacific*. Univ. of Chicago Press, 1946, 397 pp. (\$3.75).

## REVIEWS

GLACIAL GEOLOGY AND THE PLEISTOCENE EPOCH. By RICHARD FOSTER FLINT. John Wiley and Sons, Inc., New York, xviii and 589 pp., 88 text figures, 30 tables, 6 plates, 1947 (\$6.00).

Man is a creature of the Pleistocene and most students of the origin, development, environment and chronology of man recognize the necessity of understanding the physical world in which he has lived. The record of this physical history lies largely in the surface features and geologic deposits of the Pleistocene. As such it falls within the province of the geologist.

Professor Flint, Yale's extremely able and active glacial geologist, has provided an excellent summary of information on the Pleistocene. The physical anthropologist will find it an authoritative and handy reference to the many phases of Pleistocene geology and particularly to glacial geology. He will, I believe, find it as easy to read as it is to use even though he may not have had formal training in geology.

The author treats the Pleistocene quite "frankly from the point of view of glaciation, the outstanding characteristic which distinguishes the Pleistocene from the epochs which preceded it." The reader will find well-documented discussion of almost all phases of glacial action, including the nature of glaciers and their movement, deposition and erosional features of glaciers, drainage changes due to glacial activity, and chapters on glacial stratigraphy in North America, Europe and other continents. Pleistocene geology outside the glaciated areas is also discussed with special emphasis on changing sea levels of the immediate geologic past and on glacial and interglacial climates. Although by training and profession a geologist, Prof. Flint has not hesitated to include evidence of the changing fauna and flora of the Pleistocene in so far as it contributes to our understanding of the physical events of the period.

In addition to defining the Pleistocene in climatic terms, Flint suggests a return to Lyell's concept of the Pleistocene as embracing all time which has elapsed since the Pliocene. Such a step reduces the unwieldy and often meaningless terms of "Recent" and "Post-glacial" to local or informal time designations, a procedure which appeals to this reviewer.

Chronology, relative and absolute, is of extreme importance to the physical anthropologist. Flint approaches this problem conservatively and from the geologic point of view. Correlations are based primarily "on geologic evidence rather than archaeologic evidence." In the present state of our knowledge this seems desirable. Furthermore the avoidance of "deduction from any theory of Pleistocene climatic fluctuation which sets up a fixed chronology of events" will be sympathetically received by many American workers. On the other hand some will find disappointing the author's lack of faith in the reconstruction of climatic variations outside the glacial boundary on the basis of the changing nature of streams. Although admittedly beset with many pitfalls this method is often all that may be available to the geologist or the anthropologist. It becomes increasingly important to the anthropologist when, as so often happens, human remains are related to the changing regime of streams. Continuing field studies suggest to this reviewer that stream terraces as chronologic and climatic indicators have a much greater validity than is accorded them by Prof. Flint.

Despite the ever increasing amount of material available on the Pleistocene this text should stand as a standard reference for a long time to come. It affords the reader not only a thoughtful and scholarly summary of the facts established, theories held, and hypotheses advanced within the field of glacial geology, but also a well chosen list of references at the back of the text it will lead him to source material if greater detail is desired. Furthermore the index enables rapid location in the text of material, whether it be on glaciers in the Hindu Kush, the fluctuation of solar radiation, or the composition, distribution, form and origin of drumlins.

SHELDON JUDSON  
University of Wisconsin

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MIRROR FOR MAN: THE RELATION OF ANTHROPOLOGY TO MODERN LIFE. By CLYDE KLUCKHOHN. Whittlesey House Inc., New York, 300 pp. 1949 (\$3.75).

Whenever a leading figure in any field writes a popular book on his profession, the result is of immediate interest and great concern to his colleagues. The concern is that the presentation be adequate and undistorted, and the interest is in the author's integration of his material and in his point of view. On both counts *Mirror for Man* rates high marks from anthropologists of practically every persuasion.

My own enthusiasm for this book stems in part from my conviction that introductory works and liberal education in general should be couched in terms of what questions investigators are asking, why they are asking them, how they are trying to find the answers, and the reasons they use the methods they do. For the most part Kluckhohn takes this approach and covers the entire field of anthropology.

Further, since he uses relatively little data, the sequence of ideas and the author's views stand out in sharp relief. The reader with no background in anthropology can get a well rounded idea of what the field comprises and also some conception of anthropologists as a breed. The professional anthropologist, on the other hand, can fill in the background with his own knowledge and appreciate the eminently sane and comprehensive approach of a very erudite and well balanced colleague.

For this journal detailed discussion is reserved for the author's treatment of physical anthropology. Throughout the whole book Kluckhohn insists that the biology of man is inextricably bound up with his behavior and with his cultural development. The specific treatment of physical anthropology is presented in two chapters, and its various subdivisions are discussed. Although regretting the necessary brevity, the physical anthropologist will find little at which to cavil. In my opinion, however, the chapter *Race: a Modern Myth* is not in harmony with the rest of the book and has some serious weaknesses which lie chiefly in the manner of its presentation rather than in its actual content. An anthropologist reading this chapter carefully will find it sound, but a lay reader might easily finish it with some drastic misconceptions.

To begin with, the choice of title is unfortunate, for in contrast to the other chapter headings it suggests a bias which is also indicated by the relative weights given to certain parts of the discussion, even though certain brief but flat statements made by the author are sufficient to clear him of such a charge. There is, for example, an extended discussion of the inadequacy of, and the discrepancies between, the various classifications of races which any person biased against the concept of race will embrace whole-heartedly, while he might easily miss the author's brief but unequivocal assertion that he believes in race and race differences.

Another key concept which is implied in this discussion, but which is not clearly expressed, is that since racial classification is on a subspecies level of abstraction (Kluckhohn indicates clearly that he is a lumper rather than a splitter), a great number of variable criteria are involved. It seems to me that a brief statement that race classification is merely a part of the zoological classificatory



scheme, that zoological classification is based upon morphological resemblances, and that each series of categories is equivalent to a level of abstraction in which the number of criteria has been increased, would do much to set the meaning of race in its proper perspective. The author's acceptance of the three main racial stocks would then make sense; and the various attempts to isolate subtypes not only becomes understandable, but the inherent difficulties in the procedure become intelligible when it is recognized that disagreements also appear much higher in the classificatory levels, such as among the orders and families. It would also have helped if he had hammered home the underlying assumption of classification: that the greater the number of resemblances and the greater the intensity of those resemblances the greater the degree of presumed relationship.

As it is, the author's suggestion that genetic analysis be used loses considerable force, for racial classification is merely a very small part of a much larger scheme which is based chiefly on morphological resemblance. Although genetic analysis should be used wherever possible to validate relationships presumed from specific resemblances, its application to populations is not yet feasible except for a very few characters. While the composition of gene pools may eventually throw valuable light on race groupings, the number of criteria involved and the great degree of intermixture render it doubtful that the results will be much more definitive or much more satisfactory.

The value of racial analysis is also too easily shrugged off as classification for classification's sake and therefore sterile. Kluckhohn is acutely conscious of the abuses to which physical differences and the race concept have been put in order to justify slavery, oppression, and the like, and it seems to me that the more we actually know about race the better. Further, while mixed populations may result in relatively unstable blends, the race concept, when carried backward in time to include skeletal material from various periods, has proven itself a valuable tool of historical and archaeological research and interpretation. His mention of hybrid vigor with regard to race crossing implies considerable genetic difference and weakens his minimization of physical distinctiveness. At least some of the regional types in this country cited by Kluckhohn as a sign of instability seem to stem from the common heritage of specific immigrant groups. It would also have been of value if the recognition of breeding populations, such as nations, as potentially race-formative units were more forcefully expressed.

Still another point which might well confuse the lay reader is Kluckhohn's treatment of the relationship between physical type and character. On page 111 he suggests a negation of such a relation-

ship, although in his previous discussion of constitution he has tentatively accepted it. Later he splits his argument so that on page 122 he makes the well known point that there is no good evidence for racial differences in mentality, but it is not until page 125 that we find the converse, that there is no good evidence that there isn't. Here Kluckhohn goes a step farther and suggests that there may be certain mental facets, such as musical ability, in which racial groups may differ, a proposition, incidentally, with which I am in hearty accord. The separation of these points is such that the reader might easily miss the issues involved.

I should like to repeat that I consider Kluckhohn's grasp of physical anthropology to be extensive and his interpretations both sympathetic and sound. My real criticism of the race chapter is that in a book devoted to explaining the field of anthropology to the layman a slight polemic quality was allowed to creep in, which can easily give the uninformed reader a false impression of the author's stated views.

Kluckhohn himself is too experienced a hand not to realize that people with violent prejudices will not read carefully a chapter which attacks those most cherished prejudices any more than most race-prejudiced students will knowingly sign up for a course which deals with race prejudice. Furthermore, the few who do will not be converted.

To sum up, I would like to see this particular chapter rewritten so that its various themes are more sharply defined and its various parts brought into a more even balance. Above all I would like to see the heading changed, for I must confess that I am growing a little tired of seeing the race concept labeled a myth only to find it accepted as a reality in the discussion.

In general, however, I consider that *Mirror for Man* is a presentation of anthropology to the public which well justifies the Whittlesey House award, and that Clyde Kluckhohn makes an excellent spokesman for the profession.

ROBERT W. EHRLICH  
Brooklyn College

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A NEW THEORY OF HUMAN EVOLUTION. By SIR ARTHUR KEITH. Philosophical Library, New York, x and 451 pp., 1949 (\$4.75).

In this series of essays, completed on his eighty-first birthday, Sir Arthur Keith has devoted himself to the problems of the causes of human evolution. Keith tells us that as early as 1908 his interest

was changing from anatomical comparisons of man and apes to the pursuit of "the machinery of human evolution." Suggestions of the importance of local, inbreeding groups as evolutionary units were published in 1916 and the hormone theory of racial origins in 1922, but the majority of Keith's published works continued to be concerned with structure and phylogeny. The present volume was foreshadowed in "Essays on Human Evolution," published in 1946, but, as Keith himself puts it, that volume "was a superstructure; the present volume is an exposition of the fundamentals on which that superstructure is based." The human phylogeny which is presented here is fundamentally different from that in Keith's earlier writings. The differences are due in part to new discoveries but to a greater extent to the "new" or "group" theory of evolution.

The "new theory of human evolution" may be sketched as follows. Originally, small local groups formed the units of evolution. Each had its own territory and was inbreeding. Under these circumstances genetic changes would be preserved. If advantageous, the new character would become general. If deleterious, the small group would become extinct. Rapid evolution was made possible by a very large number of competing units. This was the situation during most of the Pleistocene. A second stage in evolution came with the amalgamation of the small local units into tribes. There were a vast number of tribes all over the habitable world. Each had its own territory, was inbreeding, and was separated from its neighbors by different language and customs. The group, now a tribe, continues to be the evolutionary unit, the team whose struggle leads to success or failure for all the members. The rate of evolution is slower than in the first stage because of fewer units and greater numbers. Finally, in a very late stage, coming after agriculture and complicated technology, the evolutionary unit becomes the nation. The rate of evolution is further decreased.

The explanation of the groups lies in the human mind. Human nature is dual, kind within the group and aggressive to outsiders. These two principles are the result of evolution, the altruistic qualities having been selected for use within the group and the belligerent ones for relations with other communities, tribes, or nations. The mental qualities are both a product and a cause of evolution because human nature made it possible for the group to work as a team and prevented local groups mingling. The isolation, which made segregation possible, is the result of the inherited nature of man (not of geography or other isolating mechanisms). Patriotism is the modern form of the in-group feeling which made tiny local groups view all others as enemies.

The human lineage, made possible by social isolation of genetic changes, is as follows: 1, Small-bodied anthropoids separate from monkeys (close of Oligocene). 2, Large tree-living anthropoids (Miocene). 3, Ground-living anthropoids (early Pliocene). 4, Pre-human anthropoids. These are the australopithecine man-apes, which Keith calls "Dartians." Groups of Dartians migrated out from the African homeland in the latter half of the Pliocene. The Dartians were separated in 5 major areas: Africa, Australasia, Indoasia, Sinasia, and Caucasias. Evolution from Dartian to modern race took place separately in each of the areas. There was parallel evolution in each area from middle Pliocene times to the present. In the final phases there was convergence so that the living races are more alike than their ancestors. A migration of orang-like Dartians to Europe is postulated to account for the Piltdown fossil. This line became extinct. The American Indians are a late derivative of the Sinasian group.

Using the phylogenetic tree in "New Discoveries" to represent Keith's earlier views makes it clear that several major changes have taken place since 1931. Great ape and human stems are now separated in the late Miocene, instead of the Middle Oligocene. The Dartians are given a key role in the evolution of all modern groups, rather than relegated to the ape line. The Java Man, Pekin Man, and Neanderthal Man are now considered as directly ancestral to the race which subsequently occupied the same area. These fossils are direct ancestors of Pleistocene age. Formerly, they were considered the ends of lines which separated from the main stem far back in Pliocene time. Keith has given up the idea of early modern man, believing that Galley Hill is modern and that the London and Swanscombe skulls are of uncertain racial affiliation. Late European Neanderthals are still thought of as a side branch. The Neanderthals which were ancestral to the Caucasoids were most like the Mt. Carmel fossils, but earlier and further to the East.

Naturally, it is impossible in a brief review to do more than give a few of the most interesting ideas from "A New Theory of Human Evolutions." It should be stressed that it represents a major departure from Keith's earlier theories. With regard to the arrangement of fossil men and races, Keith's ideas are now very close to those of Gates and Weidenreich. We seem to have passed through an era when ancient types of men were all put on side branches, and to have entered one in which nearly all fossils are regarded as direct ancestors. It seems clear that in Keith's thinking the adoption of the group theory (isolation as a function of the group, the importance of population size, and the linking of moral and physical evolution) caused him to change his views of human lineage. But, since



he had the idea in 1915, why did the change not come sooner? And why did Gates and Weidenreich come to such similar conclusions, at about the same time, without the benefit of the theory? Perhaps conclusions regarding man's ancestry are more a function of changing climates of opinion than we usually think.

In evaluating the "new theory," one may point out that Keith's groups parallel the populations of the geneticist. The relation of population size to rate of evolution has been extensively investigated, and the conclusions are essentially the same as Keith's, except that the highest rates probably are present when there is more inter-group communication than Keith postulates. The physical differences between many human groups show that there has not been random mating between humans. However, I can see no evidence to suggest that isolation was ever complete, especially over great lengths of time. To take but one example, Java Man and Pekin Man are placed in separate lines, stretching back to mid-Pliocene Dartian ancestors. Since the Sino-Malayan and Indo-Malayan faunas show that many animals moved freely to and from Java in the Pleistocene, there seems little reason to believe that the case was otherwise with man. Furthermore the similarities of Pleistocene stone industries show that early men were in contact, at least to some extent. Actually, the races which Keith describes correspond to the populations of major geographical regions and not to any known tribe or nation. If I understand the work of social anthropologists correctly, the moral and mental characters which Keith refers to are due to learning and conditioning. There is no need to infer that they are more permanent than the social conditions which produce them.

S. L. WASHBURN

University of Chicago

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LES PEUPLES EUROPÉENS: LEUR PASSÉ ETHNOLOGIQUE  
ET LEURS PARENTÉS RECIPROQUES D'APRÈS LES  
DERNIÈRES RECHERCHES SANGUINS ET ANTHROPO-  
LOGIQUES. By NICOLAS LAHOVARY. Editions de la Baconnière,  
Switzerland. 687 pp., about 50 unnumbered text figures, about 10  
tables, table of contents but no index, 1946 (26 Swiss francs).

This book represents an attempt to organize a vast mass of material. The sub-title would lead the reader to suppose that blood group data would be given special consideration, and it is true that pp. 75 to 193 are devoted to a discussion of the anthropological use of blood grouping. The results utilized are mostly those of the clas-



sical A, B, O system, but some mention is made of the M, N types and other blood factors.

It has not escaped the notice of Lahovary that the frequencies of O, A, and B can be practically the same in races which are widely different. He postulates, however, that the antigen B in such populations as the Negro "differs in intensity" from the B in European populations having about the same frequency. There seems to be no experimental support for this hypothesis, and the reviewer has found no evidence for it in tests on non-European races. (The sub-groups of A are another matter, but their distribution does not help the author's thesis much, either.)

The contribution in the first part of the book which the author considers his most original consists in the construction of an "index of difference" between different populations, which is calculated by taking the sum of all the differences in O, A, B, and AB frequency for the two populations. It is to be feared that blood grouping experts and geneticists will not take a very enthusiastic view of the new "index."

Lahovary sticks pretty closely to European populations in his study, and between them is able to find satisfactory "indices of difference." Had he ranged farther afield, his results, at least for the O, A, B groups, would have been more disconcerting.

The most original point of view of the author, probably, is that there exists good correlations between the variations in Europe of frequencies in the blood group genes and the other, more conventional, physical anthropological characteristics which have been in use longer. In the opinion of the reviewer, however, this is in general not true, and by insisting on it Lahovary misses his chance to be the first to make a usable definition of races primarily on a serological basis.

Pages 197 to 687 are primarily devoted to a consideration of physical characters other than blood groups, and to linguistics. If the field were not so far from the reviewer's own knowledge, he might be inclined to question some of the linguistic conclusions.

Altogether this is an original and stimulating book. The student will find in it much that is new, much that is old, and much that is controversial. It leaves the races of Europe pretty much as they were, but offers a few startling conclusions such as the "Mediterranean" origin of the Scotch.

WILLIAM C. BOYD  
School of Medicine  
Boston University

ACCLIMATIZATION IN THE ANDES. HISTORICAL CONFIRMATION OF "CLIMATIC AGGRESSION" IN THE DEVELOPMENT OF ANDEAN MAN. By CARLOS MONGE. Translated by Donald F. Brown. The Johns Hopkins Press, Baltimore, Md. xix + 130 pp. 1948 (\$2.75)

As noted in an appreciative foreword by Dr. Isaiah Bowman, "Three themes are interwoven in this . . . account of altitude effects on man. They are, (1) the conclusions drawn from the experimental work of the Institute of Andean Biology, of which Dr. Monge is director; (2) the evidence in the chronicles of early Peru that the fair treatment of natives (*sic*) was one of the earliest policy conceptions of Inca government; and (3) successive colonial and republican governments of Peru . . . have largely neglected problems of human conservation that arise among the highland population." It may be said that most of the book concerns the second "theme." According to the author, "'clinical aggression' (is the effect) against persons who go from the upland to the coast, or vice versa." What is of special interest to physical anthropology, it seems to me, is Monge's insistence that the "Man of the Andes possesses biological characteristics distinct from those of sea-level man." That, "Altitude, barometric pressure, humidity, solar radiation, ionization of the atmosphere, all these elements of the Andean climate have evolved an ethnic type with morphological and biological characteristics distinct from those of other groups that people the earth."

Now, there is no question about the great influence of high altitudes on man, and the need for adaptation, or, as Monge insists, acclimatization, in order for him to live and breed successfully in this natural environment. Monge points this out with respect to the sterility and relative debility of man, and other animal forms, too, when moved from a low to a high altitude, until acclimatization together with natural selection have taken place. Too, the tendency to pulmonary diseases of high altitude inhabitants when moved to lowlands, is noted. But Monge also makes extreme claims that seem to me unwarranted by the known facts. The indigenous peoples of the Andes, for example, were and are American Indians, and no other "race," so far as known. Indeed, in this connection one may cite the studies published by J. C. Pretto and his colleagues in the *Boletín del Instituto Psicopedagógico Nacional* (Lima, Peru), especially those in volume 6, 1947. Large numbers of mestizo children, 6 to 19 years of age, were examined in cities located at altitudes ranging from 59 meters to 3,890 meters. To be sure, a greater proportion of the "raza indígena" was found in the highlands. In any case, the growth pattern was found to be much the same in the chil-

dren of both regions; puberty was reached at much the same age; the coastal children were on the whole heavier and taller and more robust, perhaps because of generally better nutritional status, than those in the highlands. On the other hand, the thoracic and abdominal perimeters and the vital capacity measurement or index were greater in the high altitude children. This picture is a far cry from the extreme view that high altitudes initiate new races of man or determine his culture. The biological and social influences of the natural environment should by all means be investigated and evaluated, and Prof. Monge is to be commended for his important studies of the effects of altitude on man in the Andes. Too, there is much historical material in this little volume that should be of definite interest to students of the region. Geographic determinism, however, whether it refers to biological man or his culture, is another matter, a very debatable one.

MARCUS S. GOLDSTEIN  
U. S. Public Health Service

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CHILD DEVELOPMENT. By MARIAN E. BRECKINRIDGE AND E. LEE VINCENT. (2nd ed.) viii and 622 pp., and 43 figures. W. B. Saunders, Phila., 1949 (\$4.00).

This book is of import to physical anthropologists for two major reasons: (1) because it deals with physical growth, and hence is in the realm of human biology; (2) because it emphasizes the interplay between physical growth and behavioral development, and hence bridges the gap between the biological and social fields. Once and for all it stresses the theme that the techniques of a human biological study are well-nigh meaningless unless expressed in terms of, or related to, the socio-psychological pattern within which the organism has its being. The volume does not sound this note overtly; it is implicit in the correlated analyses that are offered.

The authors have, I think, organized the data very well. In the first place a terrific range of material is covered: morphological, neurological, physiological, endocrinological, biochemical, psychological, cultural, educational. In the second place, the literature is tremendous (the Bibliography contains 1089 references carefully keyed into the text). All these fields, and all these references, have been analyzed, correlated, and integrated to give a smoothly-reading, evenly-paced unfolding. Were I to ask for but one additional feature it would be to suggest a cogent discussion of method and technique with reference to the measurement of physical growth, of mental test-

ing, of behavioral and emotional evaluation, and so on. (On second thought, mayhap that is another volume!)

There is in this book an assumption that the human growth pattern, generally, and the individual child's growth pattern, specifically, is a basic bio-genetic phenomenon. In the first sense *all* children grow alike; in the second sense *no two* children grow alike. Within definable limits there are a number of factors impacting upon the growth pattern; the rhythm and timing of physical growth, per se; emotional stresses; nutrition and food habits; psycho-social factors of home, school, church and community participation generally. The child merely grows because he's organic stuff; he grows in a certain way because he has a definite family-line and hence a certain bio-social framework. It is this conceptualization of endowment plus lability that enables us to define individual growth as "normal" even though it does not conform to a "norm."

We physical anthropologists tend to compartmentalize our human biology. I urge a wide reading of "Child Development" as an object lesson in a broad interpretation of biological data in a cultural and behavioral context. Let's not just measure a child's dimensions; let's measure the *whole child* in terms that the dimensions of growth are representative of a dynamic unfolding that is leading a child toward an ultimate goal: a normal healthy U. S. adult citizen.

Perhaps I've philosophized too much in this review. If I have it is because I want to get across the point that this book is more than a compendium of fact: it is a good job of analysis and synthesis, with a high order of critical judgment. If you want to be reasonably intelligent about the growth of young *H. sapiens americanus* you can't go wrong on this one.

I recommend it to you for your very favorable attention.

WILTON MARION KROGMAN  
Graduate School of Medicine  
University of Pennsylvania



PHYSICAL ANTHROPOLOGY AT YALE.—The [Physical Anthropology] Division [of the Anthropology Museum] is not one of widest appeal to the layman. The Museum's collections in it — which are notable for Connecticut, Oregon, Peru, and Hawaii — are for the most part out of sight in Osborn Laboratory where the hips and bones and skulls of ancient man are stored in upwards of one hundred boxes. Wilmarth S. Lewis. *The Yale Collections*. Yale Univ. Press, New Haven, xv + 54 pp., 1946.

PROCEEDINGS  
OF THE EIGHTEENTH ANNUAL MEETING  
OF  
THE AMERICAN ASSOCIATION OF PHYSICAL  
ANTHROPOLOGISTS

The eighteenth annual meeting of the American Association of Physical Anthropologists was held on April 11, 12 and 13, 1949, at the Wistar Institute of Anatomy and Biology in Philadelphia, Pennsylvania.

PROGRAM

- April 11 9:30 A.M. Registration  
9:45 A.M. Contributed papers 1-9.  
2:30 P.M. Contributed papers 10-17  
Evening Informal get-together
- April 12 9:30 A.M. Contributed papers 18-26  
2:15 P.M. Demonstrations 27-30  
3:30 P.M. Business meeting  
7:45 P.M. Annual dinner. Dr. Sherwood L. Washburn addressed the association on "Three Stages in Human Evolution"
- April 13 10:00 A.M. Joint session with the American Association of Anatomists at Temple University Medical School. Papers 31-33  
2:00 P.M. Excursion to the Philadelphia Zoological Garden  
9:00 P.M. Smoker. Jointly with the American Association of Anatomists
- April 14 9:00 A.M. The American Association of Anatomists presented a symposium on "Human Anatomy and Biomechanics" which was jointly sponsored by this association



## BUSINESS MEETING

The Nominating Committee, consisting of Drs. Ehrlich, Newman, Randall and Cummins (chairman), presented a double ballot. This accorded with the divided suggestions for nominees collected through the membership poll and was considered by the committee to be a democratic solution. They offered: for President, Doctors Stewart and Washburn; for the Executive Committee, Doctors Angel and Birdsell. Printed ballots were distributed. Doctors Snow and Count served as tellers. They reported the following result of the election:

President .....	T. Dale Stewart
Executive Committee .....	J. Lawrence Angel

The following were elected to membership in the Association:

Frieda Arkin	Leo Hess	Antonio Santiana
Willet C. Asling	Beckett Howorth	Neil C. Tappen
Thomas Baylek	Edward Eyre Hunt	Sheilagh Thompson
John Davies	Howard J. Kern, Jr.	Mischa Titiev
Oliver H. Duggins	Suzanna Miles	Mark Hanna Watkins
J. E. Erikson	Russell W. Newman	Robert White
Leo A. Estel	Karel Planansky	Charles G. Wilber
Menard M. Gertler	Alice Bro Racher	David M. Wolffson
Robert F. Gray	David C. Rife	Ju-kang Woo

The Treasurer's report and the report of the Auditing Committee (Doctors Cobb and Eiseley), as follows, were read and accepted.

## TREASURER'S REPORT

*Endowment Fund*

Prudence Bond .....	\$ 100.00
U.S. Savings Bonds, maturity value .....	3,000.00
	<hr/>
	3,100.00
Bank balance, March 15, 1948 .....	\$1,420.87

## Receipts

Dues .....	\$ 1,193.50	
Collected for gift to Howard University .....	234.35	
Refund from Wistar Institute .....	12.00	
Viking Fund (expenses of delegate to International Congress) .....	500.00	
Viking Fund (for summer seminar; deposited to Association account in error during treasurer's absence) .....	7,518.10	
Prudence Bond Corporation (disbursements) ...	33.80	
Interest on savings account .....	16.37	
		<hr/>
		\$9,508.12
		<hr/>
		\$10,928.99

## Expenditures

To Wistar Institute for subscriptions .....	\$735.00	
Secretarial expenses .....	133.86	
To W. M. Krogman (for Newsletter) .....	50.00	
Dues to Inter-American Society of Anthropology and Geography .....	3.00	
To Mordecai Johnson, President, Howard University (gift for Physical Anthropology) .....	234.35	
To Harold Cummins (expenses as delegate to International Congress) .....	500.00	
Returned to Viking Fund (sum deposited to Association account in error) .....	7,518.10	
To Wistar Institute (for Proceedings) .....	35.44	
To L. Cabot Briggs (rebate) .....	7.00	
Bank Charges, checking account .....	6.64	
		<hr/>
		9,223.39

## Bank balances, April 7, 1949

Checking account .....	535.44	
Savings account .....	1,170.16	
		<hr/>
		\$1,705.60
		<hr/>
		\$10,928.99

April 8, 1949  
Respectfully submitted,  
GABRIEL LASKER  
Treasurer

Certified to be as stated above.

April 12, 1949

LOREN C. EISELEY

W. MONTAGUE COBB

The Secretary of the Association was voted an appropriation of \$150 for the coming year, and empowered to spend not more than \$50 to cover his travelling expenses to the next annual meeting of the Association.

Dr. W. W. Howells, the editor of the first issue of the new monograph series, reported that the series will be entitled: "Studies in Physical Anthropology." The first number is ready and consists of the papers constituting the symposium "Early Man in the Far East," which was presented at the 1946 Chicago meeting of the Association under the auspices of the Viking Fund.

The retiring Editor of the American Journal of Physical Anthropology, Dr. T. Dale Stewart, reported that the number and quality of manuscripts received from members and non-members during the year is gratifying. He has turned over to the new Editor, Dr. Howells, the balance of the publication fund and enough manuscripts for at least one issue of the journal. The financial difficulties of the journal, which shows an annual deficit, were discussed and it was pointed out by Dr. Stewart that physical anthropologists, through membership in the American Anthropological Association, support a journal devoted to other aspects of anthropology, but that the American Journal of Physical Anthropology receives no support from that organization. The question was raised whether fellowship in the American Anthropological Association should not be divorced from journal support. The report as shown on page 275, concerning the publication fund was read by Dr. Stewart, and accepted.

Dr. Cobb moved that the association formally address the Smithsonian Institution expressing our appreciation for having acted as the home of the Journal for so many years. It was pointed out that the use of the government frank and other facilities afforded the past editors of the Journal have been of invaluable aid. The motion was carried by applause.

Dr. Howells moved a vote of appreciation to Dr. Stewart for having built up the standards and for having created confidence in the Journal. The motion was carried by applause.

Balance reported last year .....	\$201.24
Grant from the Viking Fund, Feb. 29, 1948 .....	500.00
<b>Total</b> .....	<b>701.24</b>
Paid to the Wistar Institute for the manuscripts of	
Dart, Raymond A. .... vol. 6, no. 3 (p. 259-283)	25.55
Straus, William L., Jr. .... vol. 6, no. 3 (p. 285-311)	16.50
Goff, Charles Weer .... vol. 6, no. 4 (p. 429-448)	44.18
Reynolds, Earle L., and Toshiko Asakawa vol. 6, no. 4 (p. 475-487)	30.00
<b>Total</b> .....	<b>\$116.23</b>
<b>Balance at end of year</b> .....	<b>\$585.01</b>

The nominating committee announced that Dr. Washburn has been appointed an Associate Editor of the American Journal of Physical Anthropology by the new editor and that the appointment has been approved by the Executive Committee. Dr. Washburn announced his resignation from the Executive Committee to take up his new duties. Dr. Birdsell was unanimously elected to serve on the Executive Committee for the remainder of Dr. Washburn's term.

Dr. Krogman announced that pressure of other duties obliges him to give up his editorship of the annual Newsletter. He pointed out that his experience as editor has been a gratifying one as it has kept him in touch with other physical anthropologists and he recommended the continuation of the P. A. Newsletter. Dr. Snow's motion of appreciation to Dr. Krogman for his arduous efforts was passed by acclamation. The meeting voted an appropriation of \$50 for the Newsletter for next year and authorized Dr. Krogman to appoint a suitable successor.

Dr. Krogman submitted the report of the Viking Fund Prize Committee. This report pointed out that in the past the Committee has started balloting in October of the award year and has reported in December, and that consequently recommendations have not been based on the entire previous calendar year. To obviate this and other difficulties, it was recommended that a small Award Conditions Committee,

to consist of Dr. Stewart, chairman, and Drs. McCown and Washburn, be appointed to investigate the matter, formulate a policy and report back to the Association at the next annual meeting. Dr. Lasker suggested that the past recipients of the award be added to the Committee. The acceptance of the report was voted.

Dr. Washburn reported on the plans for the Viking Fund summer seminar in physical anthropology. It is planned to hold the meetings from August 29th to September 3rd inclusive at the Viking Fund in New York and all interested members of the Association are cordially invited to attend. Dr. Raymond Dart will come from South Africa and Dr. Alexander Galloway will come from East Africa to participate. The former will bring some of the original *Australopithecus* material, as well as casts and photographs. It is planned to devote the first three days of the meeting to a consideration of the problems of physical anthropology in Africa. The last three days will immediately precede the meetings in New York of the International Congress of Americanists and it is planned to devote this part of the session to a consideration of the problem of the peopling of the New World. Dr. Lasker again mentioned that he would appreciate suggestions for the Yearbook for 1948.

The following resolution was offered by Dr. Newman:

Be it resolved that the Executive Committee be empowered to make preliminary investigations of controversies involving teaching and research in human biology and expert testimony on human biological matters by members; to inform the membership of its findings; to canvass the membership for its opinion; and to act on the basis of this opinion, expending no more than \$200 unless further authorized by a majority of the membership.

It was explained that the motion was intended to aid the Executive Committee in formulating the Association's position on such controversial issues, at the same time providing the membership with a digest of the points involved, and to preserve for the members their free exercise of professional knowledge. In discussion, however, it was pointed



out that the individual scientist should be prepared to stand back of his public statements on professional matters, that the Executive Board of the American Anthropological Association is better fitted to act for the profession, and that \$200 would be a heavy drain on current income. The motion was defeated. In further discussion it was pointed out that the Executive Committee already has the powers intended by the motion (although specified sums have not been appropriated for the indicated purpose). Those who spoke in favor of the motion indicated satisfaction if these powers were indeed inherent in the constitution of the Association.

It was pointed out that possible activities in research are limited by our professional isolation and that one way to deal with problems of research might be to associate ourselves with the National Research Council through the Division of Anthropology and Psychology. It was moved that the president head a committee to explore the matter. On passage of the resolution, President Stewart appointed Doctors Bowles and Zwemer to serve with him.

Dr. Reynolds reported as follows for the Resolutions Committee:

1. Repeatedly the Wistar Institute and Dr. Edmond J. Farris have given us occasion to be grateful for their hospitality and their efforts. Again we are happy to express our thanks to them.

2. To the American Optical Company we are grateful for the trustful loan of the opaque projector and the demonstration which it made possible.

3. The invitation to the smoker which the Blakiston Company has been gracious enough to arrange for us jointly with our brother organization, the American Association of Anatomists, on the evening of April 13, we likewise appreciate and accept with pleasure.

4. For the friendliness of the Philadelphia Zoological Garden in inviting us to its grounds on the afternoon of April 13 we are grateful, and we are happy to respond.

We hereby will that these expressions be recorded in the minutes of our session, and we direct the secretary to write accordingly to these institutions severally.

These resolutions were unanimously adopted and the meeting adjourned.

## SCIENTIFIC PAPERS

The titles and abstracts of papers read at the scientific sessions follow:

1. *Studies in physiological anthropology. I. The basal metabolic rate of the Eskimo.* Victor E. Levine, Creighton University School of Medicine, Omaha, Nebraska.

The basal metabolic rate of the Eskimo reported in the literature (+ 19 to + 33 %) is too high to be considered physiological. These high rates point either to pathological states or to lack of basal conditions of the test.

A series of tests were conducted on 23 Eskimos chosen after a complete medical examination, X-ray of the chest to rule out tuberculosis, determination of hemoglobin, red and white cell and differential counts and tests on urine for pathological components. Environmental temperature, season of the year and diet were recorded. To remove emotional elements subjects were chosen who were well acquainted with the investigator for over a year. Demonstrations were made to prove the safety and comfort of the procedure.

The subjects came to the government hospital in the evening for rest and sleep. Two to three tests were made the morning following. The first test invariably gave a very high figure but the second or third gave a normal figure for 19 natives, but a high figure for 4, due probably to apprehensiveness.

Alterations on the basal metabolic rate of normal individuals have been attributed to undernutrition, protein intake, degree of physical activity, and emotional relaxation, to climate and to race. Whatever the differences reported in the basal metabolic rate of various population groups, these do not lie inherent as racial characteristics. The differences may be made to disappear as in the case among the Eskimos investigated, when tests were carried out under carefully controlled conditions.

2. *Age changes in head hair from birth to maturity. II. Medullation in hair of children.* Oliver H. Duggins and Mildred Trotter, Department of Anatomy, Washington University, St. Louis.

More than 20,000 hairs from 16 White children of American parentage have been examined for medullation from birth to 14 years of age. These hair specimens were obtained from the vertex of the head and were submitted monthly by the parents. Between 50 and 300 hairs were examined for each subject from each of the first 7 months specimens. Following this, 25 hairs were observed from each subjects' samples at 6-month intervals.

The medullas were listed as absent, scanty, broken or continuous.

Only 38 extremely fragmentary or scanty medullas were found among 5019 hairs taken from the birth, one month and two month specimens. The number of hairs containing medullas increased from 6% at three months to 33% at 7 months. At one year 46% of all the hairs examined contained medullas. A rapid decline ensued to 23% at two years followed by a rise to 40% at 5 years after which no particular trend was evidenced.

A close correlation was found between size and medullation after the second year. This correlation did not exist from birth to two years of age. No correlation could be found between age and medulla type. Some correlation was noted between sex and medullation.

Hair taken from 16 part and full-term fetuses, 9 Negro and 7 White, revealed no medullas among the White fetuses but numerous well-defined medullas in three of the full-term Negro fetuses.

3. *Torus palatinus*. Ju-kang Woo, Department of Anatomy, Washington University. (Introduced by Mildred Trotter.)

Hard palates of 2348 skulls of 6 series and skulls of 186 anthropoid apes and 50 macaques were examined for torus palatinus. It is believed to be a normal anatomical variation and has no connection with any pathological condition.

The torus varies considerably in form and size. It is composed of a layer of compact bone on oral and nasal surfaces with intervening spongy bone. A narrow palate usually has a larger torus and a broad palate, a smaller one.

It may exist in the fetal stage, gradually increases in size from birth to maturity and then ceases to grow with age.

The female has a higher percentage of the torus than does the male, but in no series is the difference larger than 10%.

Eskimos, American Indians and Mongolians have greater percentages of the torus than either American Whites or American Negroes. The Eskimo series has the greatest percentage and the American Negro series, the least.

A case of the torus in a chimpanzee is reported.

Torus palatinus seems to be a primitive hominid character, determined by hereditary constitution.

4. *The incidence and inheritance of the palatine and mandibular tori*. Vernon E. Krah, Department of Anatomy, University of Maryland School of Medicine, Baltimore, Maryland.

The palatine and mandibular tori are hyperostoses of the hard palate and lingual surface of the mandible. A group of nearly 200 medical students was examined for the presence of these growths. Approximately 24% of the subjects had only the palatine torus, 11% had only the mandibular torus, 15% exhibited both types, while 49% showed neither type of torus. The total incidence of torus palatinus (alone or together with torus mandibularis) was 39%; that of the mandibular torus was only 26%. When present, torus mandibularis was usually bilateral, but not always of equal size on the two sides.

Data were obtained on the incidence of tori in the families of 125 of the students. Of subjects with torus palatinus only, approximately 70% were from families showing one or both types of torus. Of those with torus mandibularis only, 82% had one or both types of torus represented in their families. Where students had both tori, the families also had them in 60% of the cases. In nearly 85% of cases, students who had neither type of torus were from families without tori. The tori appear to be inherited and to be controlled by a gene which is common in the population. The two types of torus do not appear to

be independent in origin. Their transmission does not involve sex linkage. Some tests of the data indicate that the development of tori depends upon a simple recessive gene; others, however, point to an inheritance through a dominant gene (or genes) of low penetrance. Additional information must be obtained before this particular question can be settled.

5. *Anthropometric nomograph of army men.* Francis E. Randall, Climatic Research Laboratory, Lawrence, Mass.

In order to reduce anthropometry of army men to the simplest form for use by non-scientific personnel, a nomograph has been prepared to demonstrate the relationships of 24 other dimensions to stature and chest circumference. This graph is based on a series of 24,500 U. S. Army separates.

6. *Somatotype distribution among the Japanese of Northern Honshu.* Bertram S. Kraus, Department of Anthropology, University of Arizona.

Five hundred and forty-four adult Japanese males from the cities of Sendai and Morioka in Northern Honshu were photographed and somatotyped anthroposcopically. The ages ranged from 19 to 45. The Sendai sample comprised 395 individuals, the Morioka 149. With few exceptions the subjects were "white collar" workers representing various governmental and prefectural offices in the two cities.

Twenty-five somatotypes were found among the Japanese as compared with 76 found by Sheldon among 4000 American Caucasoids. Of these 25 somatotypes, 9 are "new," that is, they were not found among the Americans (Sheldon). These 9, with their frequencies in the total Japanese sample, are:

351 .....	16.2%	462 ..	.....	.5%
342 .....	3.7%	234 . . . . .		.5%
471 .....	2.0%	552 . . . . .		.2%
243 .....	1.8%	561 .....		.2%
		272 .....		.2%

There were 4 somatotypes having a total frequency among the Japanese of 58.2%. The same somatotypes among the Americans (Sheldon) have a total frequency of 1.5%. These somatotypes, with their respective frequencies, are: 361 (21.2%), 351 (16.2%), 461 (10.5%), and 252 (10.3%). The 25 somatotypes accounting for 100% of the Japanese sample have a total frequency among the Americans (Sheldon) of only 24.2%.

The mean endomorphic rating for the total Japanese sample was 3.04 (S.D. : 0.21); the mean mesomorphic rating was 5.05 (S.D. : 0.89); the mean ecomorphic rating was 1.37 (S.D. : 0.57). For the Americans (Sheldon) the respective means were 3.20 (S. D. : 1.2); 3.77 (S. D. : 1.2) and 3.53 (S. D. : 1.3). In general, the Japanese of this sample are significantly more mesomorphic and less ectomorphic than the Americans of Sheldon's sample.

This study indicates the greater homogeneity of the Northern Honshu sample with respect to body build as compared with the American samples studied by Sheldon, Seltzer and Gallagher, and Dupertuis. It further suggests the possibility of race differentiation along the lines of mean component ratings as well as of differentials in the frequencies of certain somatotype clusters.

7. *Anthropometry of extreme somatotypes.* C. Wesley Dupertuis, Western Reserve University, Cleveland, Ohio.

Anthropometric measurements were taken on 30 extreme somatotypes. In the group were 10 endomorphs, 10 mesomorphs and 10 ectomorphs. The comparison of measurement means showed the ectomorphs to be extraordinarily different from the other two groups. Differences between the endomorphs and mesomorphs occurred mainly in trunk diameters and circumferences.

Results indicated that head and face measurements and body and limb lengths failed to differentiate well between the three groups of extreme somatotypes. Lateral and antero-posterior diameters of the trunk and circumference measurements showed more differences. They were not so successful, however, as Sheldon's pin point measurements on the photographs for discriminating between morphological types.

8. *Dynamic posture positions, as demonstrated by somatotypical photographs.* Charles Weer Goff, Hartford, Connecticut.

From the files of the Statistics Laboratory of the Anthropology Department at Harvard University 31,658 body build photographs were studied for clarity and distribution of body types. Approximately 10% were used in a study of dynamic posture as portrayed in the lateral views. Tracings were made of 98 somatotypes. From this selected group those of pure body types, namely the Fat Type, the Muscular Type and the Thin Elongated Type constituted the focal points of the study series. A 4th group was also selected and traced which was called the Balanced Type, containing elements of all three pure types but relatively equated. Cross samples were taken with care to maintain complete objectivity. Mean tracings were made of each sample and an overall Mean Posture Tracing was determined by superimposition of all means. The common point used in superimposing all tracings was the lumbosacral junction.

The mean tracings thus obtained clearly indicate a center of gravity well forward of the anterior edge of the ankle joint passing just in front of the upper, anterior margin of sacrum. The muscular type demonstrated greater lumbar lordosis and less roundness of dorsal region. Chest was well elevated and the overall impression was most pleasing. The fat type proved to have a flatter lumbar curve, shorter than the thin elongated type but also showing a dorsal curve midway between the muscular and thin elongated types. The balanced type was easily located between the fat type and the muscular type in all posture components. This study indicates a characteristic dynamic posture associated with each constitutional type, confirming the descriptive analyses as proposed by Sheldon.

9. *Civilization and molar decay in western Europe and Africa.* R. E. G. Armattee, Lomeshie Research Centre, Londonderry, North Ireland. (Under a Viking Fund Research Grant for dental investigations in Africa. Read by title.)

Within the last quarter century a tremendous biological revolution has occurred to our human species. Sir A. Keith et al. ('28) have pointed out the



increasing frequency of lantern jaws and loose teeth among the English from the 18th as compared with previous centuries.

In West Africa where malocclusion and dental caries were very rare or absent a generation ago, there is today a great incidence of caries and pyorrhoea, gingivitis and dental malformation.

This has come about through the change of diet and methods of cooking introduced by the importation of corn-mills and corn-flour. This molar decay is now perceptible all over Western Europe strangely affecting the blond (fair haired) elements rather than the dark ones.

Modern molars atrophy through disuse, because modern man no longer masticates his food but gulps it. It is forgotten that the function of the incisors is for biting or scraping, and that of the canines is for shearing, and that of molars is for crushing or grinding. In an examination of 18,000 Africans only 54 showed correct dental alignment.

In fact we may now change the old statement of moral decay succeeding advancing civilization into a molar decay where pre-literate communities come in contact with advanced cultures.

10. *The structural components of hip width.* Earle L. Reynolds, Fels Research Institute for the Study of Human Development, Yellow Springs, Ohio.

The widening of the hips in females has been described frequently as one of the earliest of the secondary sex characters to appear. The chief components of this increase appear to be the rapid growth of the bony pelvis during this period, and the deposition of subcutaneous adipose tissue. The present paper examines the growth of these and other structural components in 85 girls and 67 boys, during puberty. Characteristics considered include age, weight, height, skeletal age, hip circumference, bi-iliac and bi-trochanteric breadths, thickness of the subcutaneous tissue, and various dimensions of the upper pelvic inlet, as seen in roentgenograms taken by the Thoms method. Sex differences are examined, and individual patterns of growth are described.

11. *An unusual anomaly of the superior extremity.* F. Gaynor Evans, Department of Anatomy, Wayne University College of Medicine.

An unusual anomaly was found in a Mexican girl in the village of Los Conejos, Michoacan, Mexico, during an examination of individuals reported to have two sets of permanent dentition. Although no supernumerary teeth were observed, all individuals exhibited pronounced crowding of the upper teeth. Ten females from 11 to 18 years of age were examined and one, M. B., age 11, also possessed anomalous superior extremities. Her total height was 1228 mm while the right and left extremity measured 480 mm and 250 mm in length, respectively. Fluoroscopic examination and X-ray pictures showed the following conditions. In the right extremity the radius, except for the head, all the carpals, except one of uncertain identity, and the metacarpal and phalanges of the thumb were missing. On the left side only the distal quarter of the humerus was present and the rudimentary radius was fused with the ulna. The carpus consisted of the capitate, hamate, triquetral and pisiform. The

metacarpals and phalanges of the first two digits were absent. The scapula was smaller than normal and the clavicle abnormally curved. All remaining digits on both hands seemed normal. Examination of the records of the local physician as well as the literature indicates this is a relatively rare anomaly. Possible causes are discussed.

*12. New methods for measuring alveolar arches applied to the study of skulls from Finnish Lapland.* Kalevi Koski, Helsinki University Dental School and Forsyth Dental Infirmary for Children.

The author introduces a new method of measuring the dimensions of the alveolar arch (the arch formed by the alveoli). This method is applicable to skulls with post mortem tooth loss, as well as to cranial material with intact dentitions.

In this method the anatomic landmarks include (a) the point of intersection of the tangent to the labial margins of the alveoli of the central incisors and of the perpendicular to this tangent (drawn between these alveoli) and (b) the most distal points of the alveolar margins of the lateral incisors, canines, second premolars and second molars on either side.

Employing these landmarks, longitudinal, transverse and oblique metric measurements can be made and some angles can be measured. From these measurements several new indices have been devised. Thus it is possible to measure the absolute size of the alveolar arch and the arch segments corresponding to the tooth groups. Additional indices have been made to express the interrelationships between the maxillary and mandibular alveolar arch dimensions.

This method has been employed in a study of more than 200 Lapp crania at the Department of Anatomy, Helsinki University. The findings indicate that the measurements and indices give a rather complete description of the alveolar arch.

*13. Morphological, hormonal and biochemical interrelationships in coronary artery disease.* Stanley M. Garn and Menard M. Gertler, Massachusetts General Hospital, Boston, Massachusetts.

Since anthropological techniques are largely descriptive, they have been employed extensively in the study of individuals who have experienced coronary artery disease under the age of 40, in the belief that a complete description of this population could reveal factors common to such individuals. This group is largely male (ratio 25:1), and these males are characterized by reduced vertical measurements, augmented horizontal measurements, and an elevated weight-to-height ratio without obesity. The thoracic measurements are particularly indicative of this laterality of build. Furthermore the peripheral measurements are reduced disproportionately, and the wrists are relatively and absolutely thicker.

Somatotype and body-build analyses of the group confirm the metric indications of laterality. Ectomorphy, either scaled or observed, is especially low, and ectomorphic dominances are nearly absent. Endomorphy is not especially

high; extreme non-muscular endomorphs are absent from the group. Mesomorphy is high, with nearly all ratings being moderate or above. Thus the second component or mesomorphy appears to be most involved. Analysis of the athletic interest show a majority with creditable showing in school or non-professional major sports, as would be expected. Occupations of the group show high "masculinity" ratings on the Terman-Miles score.

Hormonal and biochemical studies show comparable differences in steriods, uric acid and other blood constituents. In comparing this group to comparable "normals," it has been found that part of the difference may be a function of physique; body mass and serum uric acid are significantly positively related. Thus disease, physique and metabolism may be directly interrelated.

14. *Further studies of the blood groups of the Eskimo.* Victor E. Levine, Arctic Research Laboratory, Office of Naval Research, Point Barrow, Alaska.

In 1948 tests were made at Pt. Barrow on 501 Eskimos (329 said to be pure and 172 known to be mixed). The results follow:

PURE BLOODS: Per cent—O, 40.73; A<sub>1</sub>, 47.11; A<sub>2</sub>, 0; B, 9.73; A<sub>1</sub>B, 2.43; A<sub>2</sub>B, 0; M, 59.27; MN, 37.08; N, 3.65.

Gene frequencies—p, 0.299; q, 0.072; r, 0.638; m, 77.8; n, 22.19.

MIXED BLOODS: Per cent—O, 31.40; A<sub>1</sub>, 52.91; A<sub>2</sub>, 1.74; B, 5.23; A<sub>1</sub>B, 8.72; A<sub>2</sub>B, 0; M, 43.60; MN, 47.10; N, 9.30.

Gene frequencies—p<sub>1</sub>, 0.352; p<sub>2</sub>, 0.015; q, 0.045; r, 0.560; m, 67.15; n, 32.85.

All the 501 Eskimos proved to be Rh positive. Rh variants determined on 108 pure bloods and 89 mixed bloods gave the following results:

PURE BLOODS: Rh<sub>0</sub>, 0; Rh<sub>1</sub>, 45.4; Rh<sub>2</sub>, 33.3; Rh<sub>1</sub>Rh<sub>2</sub>, 21.3

MIXED BLOODS: Rh<sub>0</sub>, 1.1; Rh<sub>1</sub>, 51.7; Rh<sub>2</sub>, 30.3; Rh<sub>1</sub>Rh<sub>2</sub>, 16.9

Type N is lowest in the 100% Rh positive Eskimos, American Indians and Aleuts (W.S. Laughlin). Rh<sub>0</sub> is absent among the pure Eskimos and among the Ute Indians (Matson and Piper). Admixture among the Pt. Barrow Eskimos showed up in the appearance of subgroup A<sub>2</sub> and in the higher incidence of type N.

15. *Physical anthropology of the Aleuts and of their predecessors.* William S. Laughlin, Harvard University.

Physical examination and blood grouping of the Aleut populations of Attu, Atka and Nikolski, conducted by the Peabody Museum Aleutian Expedition of 1948, makes possible the formulation of three observations, concerning these people.

1. Traits of the Pre-Aleuts, identified by Dr. Aleš Hrdlička from skeletal materials recovered from Aleutian village sites, persist in the living, western Aleuts in easily observable form. The western Aleuts are smaller in all facial diameters and possess a lower cephalic index. In these differences they approach the Pre-Aleuts. The difference between eastern and western Aleuts is known from historical descriptions, such as that of A. Tarenetzky. The persistence of their traits in the living Aleuts was predicted by Dr. Hrdlička.

The Aleutian Islands consists of two sub-breeding populations, an Eastern and a Western. Consequently the traits of the Pre-Aleut have persisted in

observable form only in the western Aleuts. Different dialects and cultural traits serve to enhance this division. The Aleuts, relatively recent arrivals from the East, were most numerous at this end of the chain. Though the physical and cultural remains of the Aleuts are superimposed on those of the Pre-Aleuts, it is apparent that many of their cultural traits preceded their arrival so that no trait correlation is possible between the two physical types and the two major archaeological periods.

2. The identification of Aleuts as Eskimo is substantiated by their blood groups and by their anthropometry. In the gene frequencies of their blood groups (A, B, M, N), they are similar to most Eskimo, almost identical with the Nanortalik Eskimo and unlike Indians. Anthropometrically they are most similar to the brachycephalic, southwestern Eskimo of Bristol Bay. The principal differences occur in the diameters of the head. In the possession of small hands and feet, large relative sitting height and other morphological features they are typical Eskimo.

3. The greater degree of non-Aleut mixture in the Eastern Aleuts, known historically, is demonstrated in the blood groups. The shift in gene frequencies of blood groups of relatively pure eastern Aleuts contrasted with relatively more mixed eastern Aleuts follows the same pattern as that of other groups of Eskimo in these two categories.

16. *New studies on the racial distribution of the Rh-Hr blood types.* A.S. Wiener, Brooklyn, N. Y.

17. *Studies in physiological anthropology. II. The blood lipids of the Alaskan Eskimo.* Charles G. Wilber and Victor E. Levine, Arctic Research Laboratory, Office of Naval Research, Point Barrow, Alaska.

In the past the problem of racial relationships has been attacked by means of physical measurements. With the exception of work on blood types, there is very little information available concerning the possible biochemical differences among the various races. In an attempt to throw some light on the problem, analyses of blood lipids from 70 Alaskan Eskimos were made.

The following values of the lipids, in milligrams per 100 cm<sup>3</sup> of the plasma, were obtained: (averages for males are given first), lipid phosphorus 14.9, 15.4; phospholipid 372.5, 385.0; total cholesterol 202.8, 233.5; total fatty acids 746, 711.7. There is no statistically significant difference between the sexes.

The values indicate a high level of lipid metabolism in the Eskimos tested; this may result from the high meat diet at the time. On the other hand the high total cholesterol indicates a comparatively low basal metabolic rate. This conclusion is in accord with the contentions of Levine who found normal BMR's in the Eskimos of Alaska.

A comparison of the ratios of one lipid to another shows that there is less cholesterol in proportion to other lipids in the Alaskan Eskimo blood than in the blood of whites. Conditions in the field made it impossible to eliminate the factors of diet and preabsorptive conditions from these results. Further work along this line is being pursued.



18. *A Soviet Russian anthology on the races of man.* Earl Count, Hamilton College.

19. *Variations in the time of appearance of ossification centers.* Charles R. Noback, Department of Anatomy, Long Island College of Medicine.

Although an ossification center appears at a relatively restricted time in the life history of an organism, it is an established fact that there are variations in its time of appearance. Among the factors influencing the appearance of ossification centers are sex, thyroid gland and state of health.

In this discussion there will be described some experiments on prenatal and postnatal rats indicating that induced hypothyroidism may delay the appearance of an ossification center while induced hyperthyroidism may result in the appearance of an ossification center before its normal time of appearance.

Certain contradictory aspects of the relation of sex and certain gonadal secretions to the time of appearance of ossification centers will be discussed.

20. *Trophy skulls of Ohio Hopewell.* Charles E. Snow, Department of Anthropology, University of Kentucky, Lexington.

Some 30 trophy skulls from Ohio Hopewell graves are now known. Of these, 4 definitely appear to be females. So-called trophy skulls are found as unusual burial associations accompanying complete Hopewell burials placed under or in large earth burial mounds. They are not unique to Hopewell, but appear with earlier Adena burials and in other cultures in North, Middle, and South America. As a prehistoric culture, Hopewell in Ohio holds a unique place in American archaeology because of its great material wealth, its widespread trade contacts, the extensive earthworks, and numerous artifacts of high artistry—all evidences of a well integrated and highly organized society.

Trophy skulls all bear signs of their preparation, often quite elaborate; incisions (skinning marks?) scraping and polishing striae (parallel and criss cross) especially along the borders of muscular and ligamentous attachments, drilled perforations, gouge and peck marks, sectioning and burnishing—one, some or all in combination. Bone irregularities and spines are found ground off. Red ochre applications and copper stains (some from ear spools) serve further to distinguish some of these interesting artifacts. Drill holes through the mouth parts and vault may have served for the passage of cords or thongs for jaw articulation and/or the carrying or mounting of the skull. The vault perforations may have held copper ornaments, feathers or some ceremonial decorations.

The trophy skulls resemble those from ordinary Hopewell skeletons, showing the same variety and kinds of physical types and head deformation. Whatever their purpose, still unknown, whether religious, memorial, ceremonial, sacrificial or as ancestral relics, it is significant that both sexes are represented among the trophy skulls and that they were probably Hopewellian in origin. Various trophy skulls were illustrated by opaque projection.



21. *The blond Mandan: a critical review of an old problem.* Marshall T. Newman, Division of Physical Anthropology, U.S. National Museum, Washington, D.C.

Before the first explorers reached the Mandan villages on the upper Missouri in the 18th and early 19th centuries, they had heard tales about White civilized Indians in the western lands. The higher cultural development of the settled Mandans, skin colors lighter than the expected medium-dark coppery brown, dark brown hair and eyes instead of black, and fine hair texture rather than coarse seemed to prove these tales. The presence of an unusual amount of premature greying (achromotrichia), and the considerable infiltration of white genes from at least 1790 on helped to round out the picture of "white civilized Indians."

A critical analysis of travelers' reports on the Mandan, in the light of probabilities of human genetics, physical anthropology and archaeology does not support the view that the Mandan were descendants of the lost Scandinavian expedition of 1355-64, or of any other pre-Columbian Whites. Rather, their northern location and life in earth lodges minimized selection against light skin color, and at the same time lessened tanning and weathering phenomena. This may have made for a south-north decrease in skin pigmentation, such as seen in the Southwest. As a group, the Mandan and some other Northern Plains tribes were certainly lighter-skinned than most Indians. Within such a light-skinned group, individual variation would make for some particularly light-skinned persons—racially speaking still pure Indian.

22. *Ancient and modern man in Sinai.* Henry Field, Washington D.C.

The Sinai Phase of the University of California African Expedition operated east of the Suez Canal from December 15, 1947 to January 26, 1948. Stone Age surface sites were located between Ismailia and Abu Aweigila, in the Wilderness of Tih, and in the southwest near Abu Zenima. The most important site was at El Rawafæ in northeastern Sinai, where a superb series of typologically Lower Paleolithic handaxes was found. These discoveries prove that ancient man migrated across the land-bridge linking Asia and Africa.

Anthropometric data were recorded on 150 Beduins and 73 Jebeliye, the servants at St. Catherine's Monastery who were imported from Europe by Justinian during the 4th century of our era.

The Beduins of Sinai are remarkably homogeneous in physical type and belong to a relatively pure branch of the Mediterranean Race. The basic element is represented by a short, small-headed, dolichocephalic type with narrow forehead and face, a thin, aquiline nose with curving alae, and a slight, dark brown beard. The hair is dark brown with low waves. The eyes are dark brown and exceptionally keen and farsighted.

The final reports will be published by the University of California.

23. *The Galley Hill Skeleton.* M.F. Ashley Montagu, Department of Anatomy, Hahnemann Medical College and Hospital, Philadelphia.

With the aid of a grant from the Viking Fund the author made a study of the exact site from which the Galley Hill skeleton was recovered (1888).

This represents a stratified sandy gravel some 8 feet thick, which has been disturbed by solution of underlying Chalk. The solution of the Chalk represents a downward percolation of acid waters through the gravels. Because this process has been so pronounced at this site no original shells or bones have survived in the gravel. This is a telling bit of evidence. Why should a human skeleton alone survive?

Solution pipes (i.e., pockets of disturbed material) extend from top to bottom of the gravel. Solifluxion pockets are present at the top of the gravel. These features may have obscured direct evidence of burial.

A morphological study of the Galley Hill skeleton revealed that none of the so-called primitive characters which had been attributed to it, were in fact present. There was no evidence of fossilization. A study of the fluorine content of samples of the Galley Hill skeleton bones, compared with Pleistocene bones of known age from the same region corroborated the suspicion that the Galley Hill skeleton probably represented an interment of Holocene age.

*24. The anthropometry of the Puerto Rican population. A discussion of methodology.* Fred P. Thieme, University of Puerto Rico.

This is a review of the Puerto Rican biological and anthropometric survey carried out from June 1948 to January 1949 by a field team composed of J. E. Finkle, R. I. Murrill and Fred P. Thieme and under the general direction of H. L. Shapiro and sponsored by the Social Science Research Center of the University of Puerto Rico.

A statistically representative sample of the island population was obtained in the 3,500 male and female sample gathered from 44 different locations on the island. Thirty-five measurements and numerous observations made up the anthropometric data. A complete dental record was made. Blood pressure, temperature, red and white blood counts and differential cell counts, hemoglobin determinations, a complete examination of fecal samples for protozoa and helminths, blood grouping including the sub-types of Rh and Hr were made together with occasional chest X-rays and other additional determinations.

Sociological interview data together with nutritional background will be used to test the importance of nutrition, variation in geographical environment and racial background as it bears on the physical characteristics of the sample. In addition, medical standards for the Puerto Rican population will be developed for use in assessing the individual in terms of his own population and to establish a "bench mark" for 1948 to be used in future determinations of the changes in public health.

The importance of reliable and scientific sampling in terms of problem in this type of survey was stressed.

*25. Sex differences in the pelves of primates.* Adolph H. Schultz, Johns Hopkins University.

The ischium-pubis index and the relative pelvic inlet breadth have been studied in 450 adult and 26 sub-adult primates with sex known or reliably determined. The length of the pubic bone and the width of the pelvic inlet

grow with greater relative intensity in females than males during a short period preceding adulthood. In all species examined the averages and the extreme variations of females surpass the corresponding values of males regarding both pelvic indices. The sex differences in the ischium-pubis index are much more marked in monkeys and man than in the anthropoid apes. The relative pelvic inlet breadth shows the greatest sex differences in orang-utan and gorilla, somewhat smaller differences in monkeys and man, and the least significant differences in gibbon and chimpanzee.

The pelvic inlet of the adult female is very little larger than the head of the newborn in monkeys, gibbons and man, but in the great apes the pelvic inlet is much larger than the head of the newborn. The relative widening of the pelvis in females represents a vital adaptation to the requirements of parturition in monkeys and in man, but not in the anthropoids. In the latter the amount of specialization in the female pelvis is closely correlated with the general trend for sex differentiation in other bodily parts which is extremely marked in orang-utan and gorilla, whereas unusually little developed in gibbon and chimpanzee.

26. *Evidence of new significance of the paramolar cusp in relation to the study of man's ascent.* Albert A. Dahlberg, Department of Anthropology, University of Chicago.

In a sample of 80 Pima Indians of Arizona 25 of the individuals (31%) had paramolar cusps of varying degrees of prominence on the lower permanent first molars. Prior to this only three instances of the paramolar cusp on the lower first permanent molars of modern hominids had been reported in the literature. The cusp is very strikingly seen on *Australopithecus prometheus*, less so on *Paranthropus*, *Australopithecus africanus* and in fair degree on many *Sinanthropus* lower molars.

In the 80 Pimas, 12 revealed the cusp bilaterally on only the lower first molars, 4 bilaterally on the first and second molars, two bilaterally on the first molars with occurrence on one second molar, and 7 unilaterally on the first molars. It also occurred bilaterally 20 times and unilaterally three times on the deciduous second molars of this same group. Some of the individuals had lost their deciduous teeth, others had not yet erupted the permanent ones, so the percentage would probably be higher were a full accounting of all the molars per individual available.

Evidence of presence of vestiges of the cusp in the general white population is suggested by the pit at the gingival end of the buccal groove separating the protoconid from the hypoconid.

27. *A report of work at Swanscombe, 1948.* M. F. Ashley Montagu, Hahnemann Medical College. (Moving picture.)

28. *A method of standardizing morphological scales by means of stereophotography.* H. T. E. Hertzberg, Aero Medical Laboratory. (Demonstration of special projector with slides showing archaeological work as well as skulls and human physical types.)

29. *Anthropometric Instruments.* Morris Steggerda, Kennedy School of Missions. (Demonstration of an anthropometer and a weighing balance.)

30. *Pathological changes in nerve cells in dementia praecox and other degenerative diseases.* James W. Papez, Department of Zoology, Cornell University, Ithaca, New York. (Demonstration.)

A special technique was devised to show changes in nerve cells in mental disease not revealed by older methods. Citric acid, sodium carbonate and cresyl echt violet were used to bring out two striking features of the disease: regeneration of desoxyribonucleic acid in the surface of the nucleolus, and inclusion bodies in cytoplasm which behaved like plasmagenes.

Small pieces of prefrontal cortex were obtained from 44 mentally ill patients on whom frontal lobotomy was performed. In these specimens three stages of slow nerve cell destruction were identified. (1) An initial stage was represented by about 10% of cells with intact cell shapes containing small numbers of inclusion bodies in their cytoplasm, deformed and deeply staining nuclei usually with numerous chromatin granules and dense nucleolus. (2) An advanced stage of disease was found in about 40% of cells in layers 3 and 5. These were characterized by large, round, vesicular (swollen) nuclei and by nucleoli surrounded by rims of desoxyribonucleic acid. This activity was associated with an accelerated process of repair of cytoplasm. Tattered and often sloughed cytoplasm was filled with small, rod-shaped or curved inclusion bodies often discharged into the cell spaces. These cells showed various stages of cytoplasmic dissolution (cytolysis). (3) A terminal stage of naked nerve cell nuclei devoid of cytoplasm, dendrites and axons was represented by 50% or more of cell population. This research was sponsored by Dr. J. F. Bateman, Department of Public Welfare of State of Ohio, Columbus, Ohio.

31. *The Philadelphia program for research in child growth.* Wilton Marion Krogman, Graduate School of Medicine, University of Pennsylvania, and Philadelphia Center for Research in Child Growth.

The well-born and well-reared child is a community asset. Anything less is a liability. To this end several groups are cooperating in the establishment of the Philadelphia Center for Research in Child Growth: the Graduate School of Medicine and the Evans Institute, School of Dentistry, both of the University of Pennsylvania; the Children's Hospital of Philadelphia; the Ellen H. Richards Institute of the Pennsylvania State College.

It is planned to study the growth and development of children over a period of time at least from birth through the 12th grade. Four major areas of growth are to be explored: (1) morphological, which is bodily structure; (2) physiological and biochemical, which are bodily function; (3) psychological, which is individual behavior; (4) sociological, which is group behavior. The 4 areas, integrated, will converge on the WHOLE CHILD as an individual bio-genetic and familio-social entity.



In this paper we shall outline proposed procedures in the elucidation of each area. Special growth problems at present under investigation will be discussed and a report of progress will be presented. Special attention will be given to the organization and interpretation of the "family-line" method of investigating the child's growth status and progress.

32. *The concept of race.* William C. Boyd, Boston University School of Medicine.

As currently used by geneticists and taxonomists studying the lower forms, races are defined as populations partially isolated reproductively which differ from each other in respect to the frequency of one or more genes. If this concept is applied in the attempt to define human races, several conclusions emerge: (1) we shall not expect that every individual of one race will be distinguishable from any individual of another race, (2) we shall not expect individuals of different races to differ in regard to every characteristic they possess, (3) we shall distinguish races by the use of genetically determined characters, rather than morphological and metrical features whose heredity is still obscure, (4) we find that at the present time the various blood grouping factors, particularly the Rh factors, offer the most information as to variations in gene frequencies in different populations, (5) six genetically defined human races, geographically distributed in a plausible manner, can be distinguished, (6) future progress in physical anthropology will depend to a large extent upon progress in human genetics.

33. *Recent discoveries of fossil primates and their alleged bearing on human evolution.* William L. Straus, Jr., Department of Anatomy, Johns Hopkins University School of Medicine.

Recent discoveries in Asia, South Africa, and East Africa are considered.

The giant teeth from China, termed *Gigantopithecus*, and the huge mandibular fragment from Java, termed *Meganthropus*, have been interpreted by Weidenreich as indicating that the ancestors of modern man were giants. The recently discovered massive mandibular fragment from South Africa ("Swartkrans man") gives added interest to this problem.

The Australopithecinae of South Africa are regarded by Broom and others as erect, terrestrial bipeds morphologically approaching man.

Other interpretations of the above specimens are equally valid at the present time.

Early Miocene primates from Kenya exhibit an interesting mixture of anthropoid and Old World monkey cranial characters, with monkey-like limb bones. These animals, when more thoroughly studied, may shed considerable light not only upon the origin of extant anthropoids but also upon the origin of man.



## SYMPOSIUM ON HUMAN ANATOMY AND BIOMECHANICS

The abstracts of the papers contributed to this symposium have been published in *The Anatomical Record*, volume 103, number 3, March 1949. This symposium and also papers numbers 31, 32 and 33 were jointly sponsored by the American Association of Physical Anthropologists and the American Association of Anatomists. The symposium was organized by Dr. F. Gaynor Evans.

*Anatomy and some principles of mechanics.* E. S. Gurdjian and H. R. Lissner, Wayne University.

*The laws of bone architecture.* John C. Koch, Detroit. (Read by title.)

*Nerve supply of diarthrodial joints, with particular reference to possible functions in locomotion.* Ernest Gardner, Wayne University.

*The biomechanics of muscles.* Herbert Elftman, Columbia University.

*The vertebral column.* Arthur Steindler, University of Iowa.

*The forearm and hand.* W. T. Dempster, University of Michigan.

*The femur.* F. Gaynor Evans, Wayne University.

*Biomechanics of the foot.* John Manter, University of Georgia.

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POPULATION GROWTH OF THE AMERICAS.—There are approximately 304,000,000 inhabitants in the Western Hemisphere. Now, as for the past 300 years, it is relatively the fastest growing of the major world regions, with an annual rate of growth half again as large as the world's average annual rate of increase. The 1945-46 absolute increment of some 5,000,000 was about a quarter of the estimated world increment, although the population of the Americas is only 14% of the world's total population. Within this century, there may well be a slight decrease in the region's annual growth rate. Considered as a whole, the Americas may maintain their present proportion of the total population of the world, but the United States and Canada will furnish a gradually decreasing share of the increase, while Latin America's share will become larger.—*World population estimates*. Div. of Intern. and Functional Intelligence, Office of Intelligence Research, Department of State, OIR Report no. 4192, March 1, 1947, Unclassified.

ORAL PIGMENTATION IN NEGROES.—Clinical observations indicate that in Negroes with very dark skin colors, there is a strong tendency for the oral tissues to be highly pigmented. As the skin color lightens, there is less of a tendency for the oral tissues to be pigmented, so that in very light Negroes, obviously pigmented oral tissues are seldom observed. It is no rarity, however, to find in Negroes of very dark skin colors oral tissues that give no clinical evidences of melanin pigmentation. Conversely, some degree of pigmentation has often been found in the mouths of many members of the Caucasian group.—Clifton O. Dummett. Physiologic pigmentation of the oral and cutaneous tissues in the Negro. *J. Dent. Res.*, vol. 25, 1946, pp. 421-432.

RECENT ITALIAN PUBLICATIONS.—The following articles of interest to physical anthropology have been published recently in the *Rivista di Antropologia*, vol. 35 for 1944-47, 1947 (summaries in English):

- SERGI, SERGIO. Terminologie e divisione delle scienze dell'uomo. I risultati di un'inchiesta internazionale. (pp. 5-83)
- SACCHETTI, ALFREDO. La valutazione relativa del peso encefalico. (pp. 84-152)
- MARCOZZI, VITTORIO. Contributo allo studio dell'ereditarietà del colore degli occhi nell'uomo. (pp. 153-170)
- PARENTI, RAFFAELLO. GLI AMARANI. Contributo alla conoscenza delle popolazioni della Somalia Meridionale. (pp. 209-245).
- COSTANZO, ALESSANDRO. La statura degli italiani ventenni nati dal 1854 al 1920. (pp. 273-284)
- GALEOTTI, GUIDO. Lo sviluppo somatico degli alunni delle scuole comunali di Roma in periodo di emergenza alimentare (anno 1945). (pp. 285-295)
- LANDOGNA CASSONE, FRANCESCO. La lotta contro gli arresti di sviluppo sessuale dei fanciulli e degli adolescenti. (pp. 296-304)
- ASCARELLI, ATTILIO. L'eccidio delle Fosse Ardeatine. (pp. 305-326)
- CORRENTI, VENERANDO. L'excursione toracica dai 7 ai 12 anni in ambo i sessi. (pp. 351-359)
- . Il fattore Rh ed i suoi sottogruppi considerati dal punto di vista antropologico. (pp. 363-381)
- CATALANO, ANGELO. Sulle anomalie congenite degli arti e dei visceri. Emimicromelia con particolare malformazione spleno-mesovarica. (pp. 382-394)
- SERGI, SERGIO. Sulla morfologia della "facies anterior corporis maxillae" nei paleantropi di Saccopastore e del Monte Circeo. (pp. 401-408)
- BONARELLI, GUIDO. L'età geologica dell'uomo di Asselar è tuttora un problema *sub judice*. (pp. 409-419)
- BLANC, ALBERTO CARLO. Sull'età geologica dell'uomo di Asselar. (p. 420)
- CAPPIERI, MARIO. Le caste degli intoccabili in India. (pp. 424-429)
- CORRENTI, VENERANDO. Il "malachistometro" (nuovo apparecchio per la misura dello spessore delle parti molli). (pp. 439-442)
- MANGILI, GUGLIELMO. Di un nuovo metodo grafico craniometrico. (pp. 443-449)

# INNOMINATE FRAGMENTS OF AUSTRALOPITHECUS PROMETHEUS

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EIGHT FIGURES

## INTRODUCTION

In the course of developing the bone breccia brought back to Johannesburg from Makapansgat Limeworks during the 1948 season, Mr. James Kitching found in a small piece of the grey breccia an almost complete left ilium and the major portion of a right ischium. These fragments must have come from an adolescent australopithecine; probably from the same individual that furnished the adolescent male mandible previously described in this journal (n. s., vol. 6, no. 4, pp. 391-411), discovered in the process of the same 1948 season's work.

In discussing the adult female cranio-facial fragment of *A. prometheus* (Dart, '49a) I made reference to the erect posture of the species; and published a preliminary note ('49b) about these innominate bone elements, together with photographs of them as separate units and also in articulation with a Bush adolescent human pelvis. Further photographs appear with the present paper, as figures 7 and 8. The note also included a drawing made by Mr. B. J. Grobbelaar (with the right ischial fragment reversed and co-opted with the left ilium) in which the reconstructed left innominate bone was compared with left innominate bones of the Bush adolescent of approximately 13 years of age and of the chimpanzee at a similar stage of growth. There I said that:

"The innominate bone in *Australopithecus prometheus* is utterly unlike that of the semi-erect chimpanzee, but on the contrary re-



sembles closely that of the living *Homo sapiens* typified by the Bushman, and not only in its shape and the relative proportion of its constituent parts, but even in its actual size. Its broad antero-medially rotated external iliac surface demonstrates the enhanced development of the gluteal musculature and its humanoid disposition relative to the lateral aspect of the pelvis and thigh, which was essential for the maintenance of the erect posture characteristic of mankind.

"The discovery of this portion of the pelvis in the grey breccia from Makapansgat near Potgietersrust confirms the numerous other indications of postural uprightness in the australopithecine group; and simultaneously corroborated the discovery by Broom of an adult innominate bone of similar human character at Sterkfontein near Krugersdorp nearly 200 miles southward in the Transvaal. It further vindicates, by its closer approximation to the human form than the *Plesianthropus* innominate bone from Sterkfontein, the foregoing evidence that *Australopithecus prometheus* walked more erectly than *Plesianthropus* and had a body build and carriage closely comparable with that of the living Bushman."

Considerable evidence had already been adduced concerning erectness in the Australopithecinae. The globular skull and the relatively forward position of the foramen magnum in the original *A. africanus* showed, and the situation of the occipital condyles in the adult *Paranthropus* confirmed, a poise of the head similar to that of man. The occiput of *A. prometheus* has recently corroborated and extended for adults the evidence of improved cranial poise found in *A. africanus* and *Paranthropus*. It also had in the meantime been borne out by such lower limb bone fragments as had been found: e.g. the *Paranthropus* talus fragment from Kromdraai farm, and the *Plesianthropus* femur, whose distal extremity had been recovered at Sterkfontein.

In the meantime Broom and Robinson ('47) had made the crucial discovery already mentioned of an adult female *Plesianthropus* "skeleton with a perfect pelvis, much of a femur, a tibia, some ribs and vertebrae" and had given a preliminary account of the general appearance of the right innominate bone and its divergences from that of the chimpanzee and its correspondences with that of man. The more extended

description of these important remains has not as yet been published, but their similarity to the fragments described in my preliminary note is sufficiently apparent from the remarks of those authors (loc. cit.):

“The pelvis . . . has an ilium which is almost typically human. It is shaped almost exactly as in the Bushman, and very unlike that of any of the anthropoids or monkeys . . . the ischium is not quite human. The tuberosity is flattened in a different way from the condition in man.”

Through the kindness of Dr. Broom I have had the opportunity of examining the *Plesianthropus* innominate bone. It appears to have come from a female and was very little if any larger than that of the adolescent *A. prometheus*. Probably, therefore, the ilium and ischium from Makapansgat come from a male pelvis, and from the same male individual as furnished the adolescent mandible previously described. The three elements had not yet united at the acetabulum, and the cristal epiphysis, if it had appeared, was still separated. Although there is a definite elevation of the site of the anterior inferior iliac spine, the pitting of the upper half of this elevation (see figs. 1 and 4) indicates that it was covered at least in its upper third with cartilage in the same way as were the entire acetabular and cristal margins and also the tuberosity of the ischial fragment.

The illustrations in this paper, as in my previous communications on *A. prometheus*, have been prepared by Mr. J. G. Heim. In order to see the bone as a whole it has been necessary to reverse the dioptographic tracing of the right ischiadic fragment and to co-apt it to the tracing of the left ilium in what appeared to be the most logical position, having regard to the circular margin and hemispherical contour of the acetabular cavity. In Mr. Heim's drawing the position of the two parts at the acetabulum has been slightly altered from that published in the previous note. For the making of the dioptographic tracings the two pieces of bone were first substituted for the corresponding parts in a plaster replica of the adolescent male Bush pelvis, which has been

used throughout this work for the purpose of comparison, along with corresponding pelves of a chimpanzee at a corresponding stage of growth, of an adolescent Bantu female, and of an adult Bush female.

The first illustration (fig. 1; see also figs. 7 and 8), a lateral view of the innominate bones in chimpanzee, *A. prometheus* and Bush juveniles of comparable pelvic growth, depicts more clearly than any verbal description the profound divergence

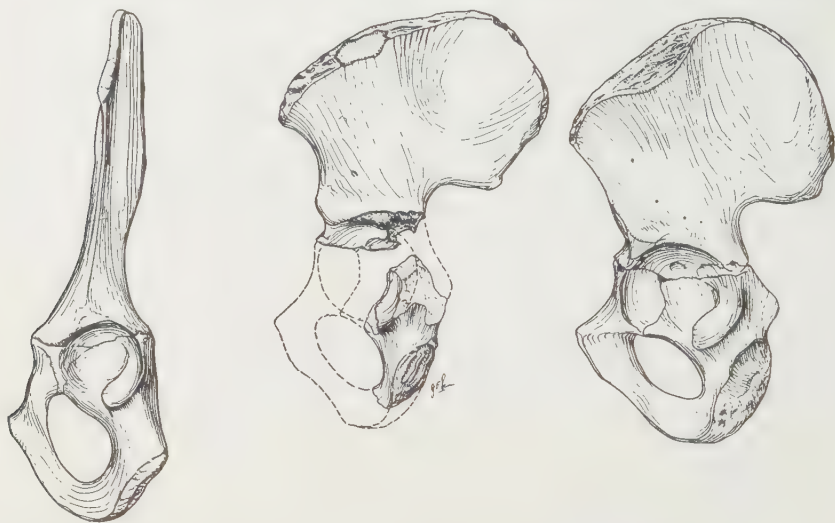


Fig. 1 Left lateral views of innominate bones in chimpanzee (left), *A. prometheus* (center) and Bush (right) male adolescents taken from dioptographic tracings of the assembled pelves (see text).

between the long and slender anthropoid and the short and squat human bones, and the proximity of the stout *A. prometheus* innominate pattern to that of man. The principal general features in which the australopithecine innominate diverges from the anthropoid and resembles the human bone are its shortening and widening, and the twisting of the iliac blade (the anthropoidal plate of Reynolds, '31) into a volute with a double concavity and from the approximately coronal body plane it occupies in anthropoids into the almost sagittal plane it assumes in man. This redoubled twist carried the

anterior superior and anterior inferior spines of the ilium from a lateral position in the chimpanzee into a truly anterior position in man and in *A. prometheus*.

Concurrently the *lateral* border of the chimpanzee iliac blade, which rises almost vertically from the anterior superior spine above the acetabular cavity at the junction of its anterior third and posterior two-thirds in the anthropoid, becomes the *anterior* border of the human (and australopithecine) iliac blade. Simultaneously the *medial* (or postero-medial) border of the anthropoid ilium becomes the truly *posterior* border of the human (and australopithecine) ilium.

For the rest, the diminished pelvic length has involved reducing the shanks of the human (and australopithecine) ilium and ischium, thereby providing an enlarged pelvic cavity bounded on either side by innominate bones with broader central pieces for articulation with the sturdier femora of the human (and australopithecine) type.

Reynolds ('31) compared anthropoid and human pelves and defined the characteristics of the human innominate bones as follows (p. 311):

"The innominates, in addition to their high breadth-height index, possess distinctively human characters in their increased curvatures, in the extreme development of the anthropoidal plate, in the greatly bent iliac axis, and in their acquisition of a new and very important development, that of the tuberosity of the ilium and the line of architectural strength which extends between it and the acetabulum."

By "tuberosity of the ilium," Reynolds apparently means *the tubercle of the crest of the ilium*. This unfortunate application of the term "tuberosity of the ilium" conflicts with its long established use in application (see Paul de Terra, '13) to the extensive roughened, tuberculated and pitted area behind the auricular surface on the sacro-pelvic aspect, which I will refer to as the *retro-auricular* surface of the ilium. Bearing this reservation in mind, Reynold's statement applies aptly to the innominate bone of *A. prometheus*, which in terms of his definition is almost, if not quite a human innominate bone.



## THE ILIUM

*Gluteal aspect*

The general features of the gluteal aspect of the australopithecine ilium, are immediately apparent in the accompanying illustrations (see figs. 1, 2 and 3) where it is compared with a Bush male adolescent, a chimpanzee at a corresponding stage of development, a Bantu female adolescent and a Bush female adult. These illustrations of the lateral and medial aspect of the bones immediately show that the australopithecine ilium is human in form and not anthropoidal. The unnatural appearance of the chimpanzee ilium when twisted into this human situation contrasts vividly with the natural appearance of the promethean ilium. But the figures also show that the australopithecine ilium is closer to the anthropoidal type than are living human ilia in maintaining a longer anterior border, a less wide shank, and a somewhat less indented greater sciatic notch. Further, in its general fan-like shape the *A. prometheus* ilium approximates the *adult* Bush (right, lower) ilium rather than the more hemispherical shape of the adolescent Bush and Bantu (upper and lower, left) ilia. The visually observed divergences between the anthropoid and human ilia are neatly and mathematically expressed by the length-breadth index of the several bones; which gives a value of 186.9 for the chimpanzee, 89.8 and 89.7 for the Bush and Bantu adolescents respectively, and 80.5 for both the *A. prometheus* adolescent and the Bush female adult (see table 1).

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Fig. 2 Comparative view of dorso-lateral (gluteal) aspects of left ilia. Upper row: left, Bush ♂ adolescent; center, chimpanzee; right, *A. prometheus*. Lower row: left, Bantu ♀ adolescent; right, Bush ♀ adult. The outlines were taken from the ilia as they lay upon the table with their gluteal surfaces fully exposed. The bones were oriented on an arbitrary horizontal 30° below the midpoint of a line drawn tangent to the inferior margins of the auricular surface and the anterior superior spine of the ilium.

Fig. 3 Comparative views of ventro-medial (sacro-pelvic) aspects of left ilia. Arrangement of specimens, and method of orientation, as in figure 2. Dioptrographic tracings were made in the same manner, but with surfaces reversed.



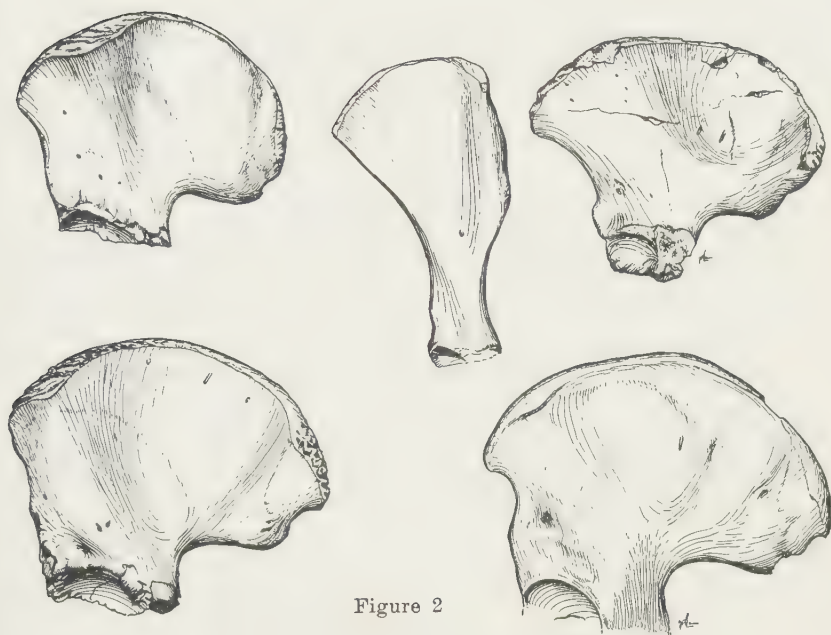


Figure 2

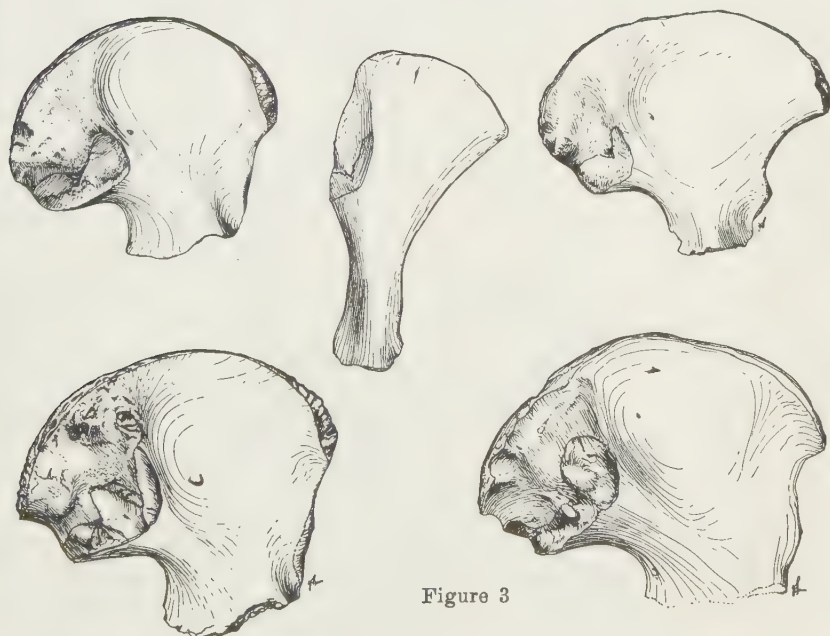


Figure 3

TABLE 1

*Comparative measurements of ilia, in millimeters*

	CHIMPANZEE	A. PROMETHEUS	BUSH ♂ ? 13 YRS.	BANTU ♀ ? 13 YRS.	BUSH ♀ ? 35 YRS.
Height of ilium	116	88	87	114	99
Greatest breadth of ilium	61	113	98	117	128
Height-breadth index	186.9	80.5	89.8	89.7	80.5
Height of ilium above determined horizontal	42	54	55	59	61
Height of ilium below determined horizontal	74	34	32	45	38
Breadth of determined horizontal	50	77	85	104	115
Breadth of pre-auricular part of horizontal	36	50	43	53	64
Breadth of posterior part of horizontal	14	27	42	51	51
Least breadth of ilium (i.e. above anterior inferior spine)	20.5	42	45	59	61
Breadth from anterior inferior-posterior inferior spine	53	71	78	91	108
Length of shaft of ilium (i.e. between auricular and acetabular margins)	60	40	35	50	ca. 51
Least thickness of shaft of ilium	12.5	17	18	18.5	16
Thickness (dorsal half of iliac blade)	3-4	4-5	4-6	6-8	4-6
Thickness (ventral half of iliac blade)	4-5	7-8	6-10	8-12	8-10
Thickness (about middle of auricular surface)	7	15.5	10	17	14.5
Length of auricular surface	27	33	41	51	52
Width of auricular surface	5-10	10-14	9-13	14-21	13-20
Width of acetabulum	30	ca. 35	40	50	45
Auricular area (in mm <sup>2</sup> )	117	252	413	580	637
<i>Percentage</i>		3.0	4.0	7.4	7.4
Retro-auricular area (in mm <sup>2</sup> )	328	831	1059	1702	1378
<i>Percentage</i>		8.4	13.3	18.5	21.3
Pre-auricular area (in mm <sup>2</sup> )	3468	5164	4131	5615	6291
<i>Percentage</i>		88.6	82.7	74.1	71.3
Total sacro-pelvic area (in mm <sup>2</sup> )	3913	6247	5603	7997	9306
<i>Percentage</i>		100.0	100.0	100.0	100.0

It is perhaps superfluous to point out that the illustrations of the ilium (figs. 2 and 3) depict the whole of the dorso-lateral (posterior in the chimpanzee) and ventro-medial (anterior in the chimpanzee) surfaces irrespective of their varying orientation in the body; they are viewed as though they were lying flat on the table, presenting the entire aspect in question.

No significance attaches to the sex of the specimens used for comparison: they are merely comparable specimens that happened to be available in the department. The adult, in particular, was from a Southern Kalahari Bush female, known to us before her death; and a plaster cast of her body is in the departmental museum. It will become apparent during the course of the description how these two Bush ilia bridge the gap that would otherwise exist between the australopithecine and other human ilia. The method adopted for orienting the ilia will be discussed in describing the sacro-pelvic surface, which appeared to furnish the most satisfactory landmarks for the purpose.

The gluteal aspect of the australopithecine bone ( $6247 \text{ mm}^2$  in area) is somewhat larger ( $644 \text{ mm}^2$ ) than that of the juvenile Bush male ( $5603 \text{ mm}^2$ ) of similar age. Apart from two recent fractures, which have torn away the posterior half of the acetabular and part of the cristal tubercular regions, the australopithecine bone is complete. It is so divergent from that of the chimpanzee, and so human in appearance that, with a few but significant modifications, the description of the corresponding portions of the innominate bones in any text-book of anatomy would apply equally well to it.

The superior border or crest (see figs. 1-6), for the attachment of the abdominal musculature, is on the whole 1-2 mm thicker than the chimpanzee crest but 1-2 mm thinner than the Bush crest at the same stage of development. The Bush crest is in its turn 1-2 mm thinner than the Bantu crest. The promethean crest is thickened over its anterior (9 mm) third and posterior (12 mm) fifth; the remainder is only 4-5 mm thick. The australopithecine iliac crest is not straight, like that of the chimpanzee (see fig. 5), but presents two curves

like the human bone: an anterior curve with its concavity directed medially and a posterior curve much deeper and with its concavity directed laterally (see fig. 5). Anteriorly it terminates in a prominent or adult human type of anterior superior spine for the attachment of the inguinal ligament and sartorius muscles (see fig. 4). Posteriorly the almost pear-shaped enlargement of the crest at the posterior superior spine symbolizes the fastening here of correspondingly hypertrophied long posterior sacro-iliac and sacro-tuberous ligaments (see fig. 6).



Fig. 4 Anterior (lateral in chimpanzee) borders of the same ilia arranged in the following order from left to right: Bush ♀ adult, *A. prometheus*, chimpanzee, Bush ♂ adolescent, Bantu ♀ adolescent. The views in figures 4, 5 and 6 are free-hand but mensurally accurate sketches of the bones without any specific orientation other than assembling them in corresponding positions to view the several borders.

The comparative illustrations (figs. 4-6) of the borders of the bone adopt a different arrangement of the series of bones from that observed in lateral view (figs. 1 and 2). For comparing the borders the chimpanzee ilium has been placed in the center; on its left stand the adult Bush female and promethean ilia; on its right the Bush and Bantu adolescent ilia in that order from left to right.

In European and Bantu ilia the tubercle of the crest forms a prominent projection 50 mm or more behind the anterior superior spine. Unfortunately the outer lip of the crest in

*A. prometheus* has been broken away for 29 mm just in the crucial vicinity where the tubercle of the crest should be situated (see fig. 4), but we can nevertheless see this characteristically human structure in the earliest or most generalized

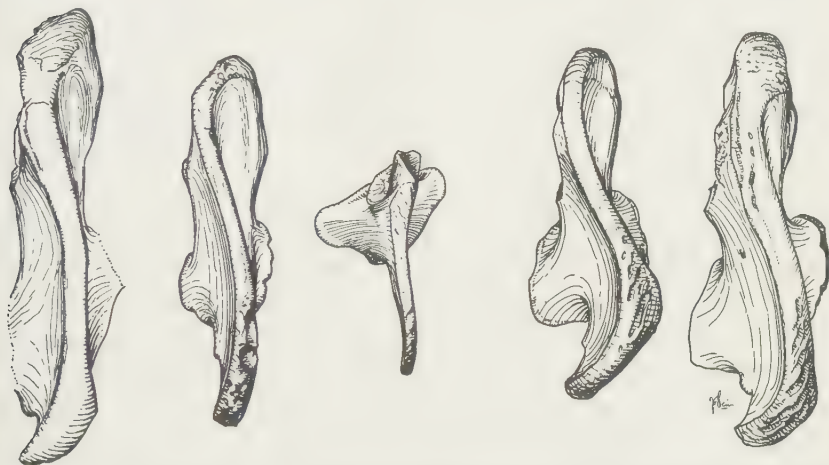


Fig. 5 Superior borders of the same ilia, order from left to right as in figure 4. The anterior extremities are at the bottom and the posterior extremities at the top of the picture.

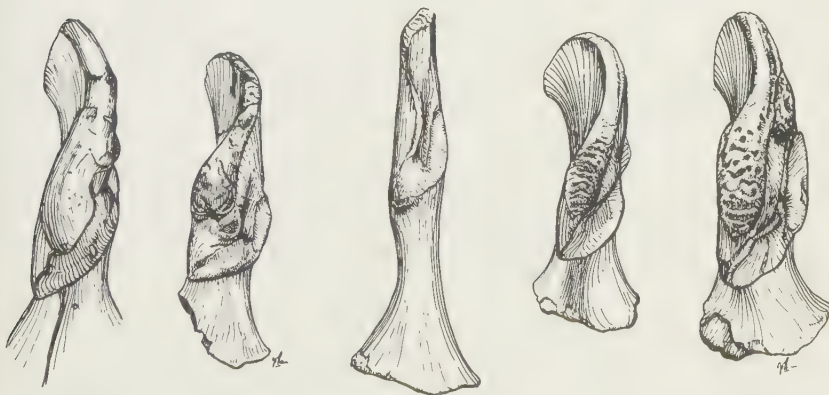


Fig. 6 Posterior borders of the same ilia, order from left to right as in figure 4. Note the human characteristics of the ilium in *A. prometheus*, second from left, and its great robusticity, especially in the auricular and retroauricular regions.



phase of its evolution. There is an appreciable generalized widening of the crest in this anterior region, and a thickening of the ilium below, i.e. between the anterior third of the crest and the acetabulum, the purpose of which (as Reynolds, op. cit., said of his "tuberosity") is to give this part of the ilium increased architectural strength; but the "tubercle" is not the prominent and distinct feature of the crest seen in the Bantu or even in the Bush pelvis, nor is the thickening of the bone sufficiently localized to form a distinct "buttress" below the tubercle, such as is present in both Bush and Bantu ilia. This lack in prominence of the australopithecine "cristal tubercle" and its "buttress" indicates that the specially thickened ilio-tibial tract of fascia lata, attached thereto in man, was probably not as sharply localized in the australopithecine as in more advanced human thighs. It is therefore of considerable comparative human anatomical interest that a broad tubercular *thickening* also takes the place of a localized tubercle in the Bush adolescent ilium. This *thickening* begins about 22 mm and ends about 45 mm behind the anterior superior spine. In the Bantu adolescent ilium no such "beginning" can be defined, the more localized tubercle being placed so far forwards that it is continuous with, and its thickening ends within 45 mm distance from, the anterior superior spine. The greatest width of the sharply localized (25 mm long and 17 mm broad) tubercle in the Bantu is therefore located at a "point" only 30 mm distant from the anterior superior spine. In the considerably smaller Bush ilium the (40 mm long and 15 mm broad) "tubercle" or *thickening* has its broader portion extending for 15 mm from a "point" 35 mm behind, to another "point" 50 mm behind the anterior superior spine. In *A. prometheus* the anterior 50 mm of the crest is thickened (10.5 mm broad) and the *thickening* has a very slight (9 mm broad) "waist" located from about 15–25 mm behind the anterior superior spine, so the "tuberculation" behind this "waist" was apparently very generalized and extremely slight.

The anterior border, as seen in lateral or medial view (figs. 2 and 3), extends in *A. prometheus* from the anterior superior spine to the acetabulum. Instead of descending almost vertically as in the Bush or Bantu adolescent, the anterior border slopes considerably backward, giving a contour more like that of the chimpanzee adolescent, or the adult Bush ilium. Further, the distance between the lower margin of the anterior superior spine and the upper margin of the anterior inferior spine is 30 mm in *A. prometheus*, whereas it is only 15 mm in the Bush and 20 mm in the Bantu adolescent. In the adult Bush this distance is also about 20 mm. So it is patent that in the living races of mankind, probably in correlation with the increasingly localized tuberculation, the middle part of the iliac crest has become more elevated or has assumed a more hemispherical contour, by a relatively greater downward and inward shift or "migration" of the anterior superior spine, twisting the anterior part of the crest — to which the sartorius and tensor fasciae latae are attached — progressively inwards. Consequently, in the deeply turned-in Bantu adolescent ilium, as seen from the anterior aspect (see fig. 4), the anterior superior spine is displaced more medially relative to the acetabular cavity as compared with the other ilia (which form an advancing series in this respect); and the anterior border itself in the Bantu presents a markedly curved outline with medial concavity (see fig. 4-6). A much slighter medial curvature is also present in the Bush anterior border. In *A. prometheus* the the border is almost straight, but not as long and straight as that of the chimpanzee; it is closer in form to that of the adult Bush female. This medial concavity appears much deeper in the Bantu anterior border because of the relatively immense size of the anterior inferior spine. In *A. prometheus* the anterior inferior spine — to which the straight head of the rectus femoris and the Y-shaped ligament of Bigelow are attached — is anteriorly situated and low but tolerably prominent, and it measures  $17 \times 8$  mm; in the Bush adolescent it is about the same size ( $23 \times 6$  mm) but is more linear in appearance; in the Bantu it is knob-like and twice

as broad ( $26 \times 12$  mm). The proximity of the morphology of the promethean to the Bush bone shows the advance that *Australopithecus prometheus* had made towards the human type is modifying the ilium in the region of the anterior inferior spine and acetabulum for the attachment of the rectus femoris musculature and the ilio-femoral ligament (compare figs. 2 and 4).

Comparison of the antero-lateral borders of the ilium, facilitated by figures 1 and 4, enables us to appreciate the great mechanical advantages which the abdominal flexors above, and the flexors of the hip-joint below, had gained in *A. prometheus* from the increased dorso-ventral length of the ilium resulting from the forward rotation of the blade and the internal twist of its anterior border. But the same process of dorso-ventral pelvic lengthening has carried the auricular surface for articulation with the sacrum backward, creating the greater sciatic notch, and has also tilted the auricular surface forward in human fashion (compare fig. 3). Thus the *A. prometheus* sacrum displayed the same type of orientation within the pelvis and relative to the vertebral column as is seen in man; in other words the pelvis had been rotated downward, and the sacrum flexed backward at the lumbosacral junction to exhibit a true sacral promontory.

It is this combination of dorso-ventral pelvic lengthening with promontorial rotation which, as Reynolds (op. cit., p. 318) noted, gives to the sartorius muscle in man:

“a long power arm for its flexor action upon the extended femur. This the much more powerful sartorius of the quadrupeds entirely lacks, as a result of the merely lateral position of their anterior superior spines and the consequent lack of any anteriorly directed power arm when the femur is fully extended. The great psoas-iliacus flexor runs, after passing in front of the pectineal eminence, strongly backward to its insertion in the femur. The forward position of the pubis which is derived from the great length of the external sagittal diameter gives to the adductor group of muscles which are attached to it a degree of flexor power which is again distinctively human; i.e., with the abductor muscles and those of external rotation in resistance, the great adductor group and especially the adductor

magnus, exerts upon the extended femur in man an extremely powerful flexor action which is comparatively slight in other animals."

These distinctively human postural muscular adjustments must have been similarly effected in *A. prometheus*.

The posterior border in *A. prometheus*, like the anterior border, as seen from the lateral or medial aspects (figs. 2 and 3), has a more strongly developed superior than inferior spine. This accentuates the "adult" fan-shaped appearance of the promethean ilium in contradistinction to the more hemispherical outline of the Bush and the Bantu adolescent ilium. In contrast with the Bush pelvises, both adolescent and adult, where the two spines almost coalesce, both the posterior superior and the posterior inferior spines are massively constructed in *A. prometheus*; the bone reaches a thickness of 15 mm in both these vicinities, as compared with 15 mm and 7 mm respectively in the Bush adolescent, and 18 mm and 15 mm respectively in the Bantu adolescent. The phenomenal posterior bone thickness (see fig. 5) is in sharpest contrast with the thin "posterior" part of the iliac blade in the chimpanzee; and exceeds even that of the *adult* female Bush ilium (15.4–7.5 mm) at the lower of these two points. This excessive thickening of the posterior part of the iliac blade was presumably provoked by a corresponding strengthening of the deeper portion of long posterior sacro-iliac ligaments, attached to this part of the bone (see fig. 6). The strong posterior pelvic ligaments (which this great posterior iliac thickening indicates) opposed, as in living mankind, the upward tilting of the lower end of the sacrum under the downward thrust imparted to the upper end of the sacrum by the vertical body weight. The strong rugosity or boss to which they are attached in *A. prometheus* is clearly evident in the posterior view (see fig. 6).

As no part of the ilium exhibits more emphatically than the posterior border the nature of its divergence from the anthropoid ilium and simultaneously its affiliation with and divergence from other human ilia, figure 6 has been prepared to illustrate:



(a) the auricular surface: it will be noted that, whereas the proficient auricular surfaces of the chimpanzee, *A. prometheus* and the Bantu adolescent provide a natural expanding morphological sequence, the slumped auricular surface of the Bush adolescent adult shows that some other "non-Bantu" process has modified their erectness but did not operate in the case of *A. prometheus*.

(b) the pear-like bulbous posterior widening of the iliac crest, terminating in *A. prometheus* well up above the auricular surface (thus leaving a distinct gap between the superior and inferior posterior spines), and mounted on an extremely robust *retro-auricular* segment of the ilium; this is a closer approximation to the Bantu pattern than to the long thin Bush pattern, which is more simian, i.e. like the chimpanzee.

(c) the hollowed-out *retro-auricular* area between the crest and auricular surface in the chimpanzee, which is replaced by a small and rather *centrally-placed* rugosity upon this surface in the two Bush ilia (compare also fig. 6). In *A. prometheus* there is a far more extensive and massive rugosity, which is more strongly marked *posteriorly*; whereas the similarly extensive and still more massive Bantu rugosity is tremendously accentuated *anteriorly*.

(d) the robusticity of the short iliac shank in the *A. prometheus* and other human ilia and the slenderness of the elongated iliac shank in the chimpanzee. Despite the absence of a well-marked cristal tubercle, the laterally-scalloped posterior part of the australopithecine dorso-lateral iliac surface (see also fig. 4) attains a depth of 12 mm as compared with 10 mm in both the Bush and the Bantu adolescent ilia. Below the posterior inferior spine in *A. prometheus* the posterior border passes abruptly forward to form a true great sciatic notch, which because of the backward bend of the iliac axis is almost but not quite as deeply indented as that of the Bush adolescent. The medio-laterally curved lower border of this promethean sciatic notch, 15 mm broad, presumably afforded origin in part to the piriformis muscle as it does in human ilia (see also fig. 1).



The gluteal surface or dorsum ilii, as already stated, is somewhat more deeply excavated posteriorly than in either the Bush or the Bantu adolescent ilium. This may also be an "adult" feature, since the adult female Bush ilium has a dorso-lateral concavity which is only slightly deeper (i.e. 1 mm deep) than that of *A. prometheus*, but deeper than in the adolescent Bush ilium. Anteriorly, and in strong contrast to the Bush and Bantu ilia, *A. prometheus* presents a relatively flattened expanse of the gluteal surface. True, it has a slightly concave contour externally in vertical section because of the slightly everted crest and the still more everted acetabular margin (compare fig. 5); but the intervening part, although relatively much reduced in height, it is almost as flat as that of the chimpanzee. In the Bush and Bantu ilia the more strongly inverted anterior superior spines and more everted iliac crests with their tubercular projections and subjacent "buttress" formation of the supporting outer osseous table give the gluteal surface here a concavo-convex shape, which is much more saddle-like in appearance than in *A. prometheus*. This inward twist of the "spino-tubercular" region of the iliac crest, far more abrupt and complete in the Bantu ilium with its forwardly-displaced tubercle, produces the incurved anterior superior spine and inward concavity of the Bantu anterior border previously discussed. The inward twist of the iliac crest is more gradual in the Bush with its slowly welling tubercle and smoothly sinuous anterior borders; but in *A. prometheus* there is no real "twist" of the "spino-tubercular" portion of the iliac crest at all, merely a gradual inward bending of the iliac plate and an almost cylindrical rather than saddle-shaped outer convexity of the gluteal surface.

The inferior and middle gluteal lines cannot be traced through their entire length in *A. prometheus* (see fig. 2) — this is also true of the Bush and Bantu adolescent ilia — but the position of the middle gluteal line can be indicated approximately and the prominent nutrient foramen lies just below the inferior gluteal line. It is only with increasing age that

these important indicators of gluteal demarcation become fully apparent but it is clear that the gluteus minimus was relatively more strongly developed than the gluteus medius in the australopithecine as compared with other human thighs — an ultra human feature — perhaps correlated with the lack of tuberculation of the crest. Even at this early age the posterior gluteal line can be traced with tolerable accuracy, in *A. prometheus* and all the human bones. This line begins about 50 mm in front of the posterior superior iliac spine in the adult European; it sweeps down 25 mm in front of the posterior superior spine and 17 mm in front of the posterior inferior spine in the Bantu adolescent; and 28 mm in front of the superior and 12 mm in front of the inferior spine in the Bush adult; its situation is only 10 mm in front of these spines in *A. prometheus*. It is a fair estimate from these facts that the iliac osseous area of attachment for the gluteus maximus is twice as great in the European adult as in the Bantu adolescent. It measures roughly 400 mm<sup>2</sup> in the Bantu adolescent and in the adult Bush ilium, while it is reduced to about 200 mm<sup>2</sup> in the Bush adolescent, and was probably not more than 100 mm<sup>2</sup> in *A. prometheus*. The gluteus maximus arises from the under surface of the iliac fascia and thereby secures an origin from the posterior part of the crest of the ilium in the chimpanzee as well as from the sacrum, coccyx and sacro-sciatic ligament. Thus, although there is little bony attachment for the muscle, it is quite large in the living anthropoids. We may however presume from the decreased size of the gluteal surface of the promethean ilium as compared with those of living peoples that, whereas the abducting power of the glutei (i.e., combined action of glutei) in the australopithecine buttock was probably as strongly developed as in the Bushman, their power in rotating the extended thigh medially and laterally on the trunk (or alternatively in rotating the trunk on the extended thighs) may not have been quite as well developed (because of the unequal development of the larger gluteus minimus vis-à-vis the presumably somewhat smaller gluteus maximus as compared with living types). In other

words the body posture may not have been quite as erect as that of the Bushman, which is not quite as erect as that of the Bantu or the European (see Dart, '37).

### *Sacro-pelvic aspect*

The principal features of the ilium as seen from the internal or sacro-pelvic aspect are exhibited in the comparative diagram (fig. 3) which confirms the deductions based on the examination of the dorso-lateral aspect. From this aspect we can study first of all the steady increase in the extent and complexity of the auricular surface. The two main parts (accessory central articular facets happened to be present and well developed in the Bantu adolescent and adult Bush specimens, and to be unusually large in the former) of the auricular surface form an obtuse angle at the anterior border in the chimpanzee but a right angle in *A. prometheus*. Reynolds ('31) pointed out "that in the apes the axis of the auricular surface is directed diagonally downward and backward, and is but slightly curved. In man it is much curved, and its posterior half runs in a direction which, if the iliac axis were straight, would be backward and upward." In respect of the form and angularity of the auricular surface *A. prometheus* is closer in form to the acute-angled Bantu adolescent than to either the more "anthropoidal" obtuse-angled Bush adolescent or the similar Bush adult. In the Bush type the problem of an increasing area for sacral articulation has been solved by an excessive expansion of the anterior element of the iliac articular surface and by excavating the articular surface to some extent so as to give the sacrum an inferior iliac ledge on which to rest. In *A. prometheus* on the other hand the posterior element of the articular surface is the broader of the two elements, as in the more erect Bantu, and its medial surface is convex from above downwards, the sacrum being fully suspended from the ilia in typical human fashion by the strong dorsal interosseous ligaments.

The method of orienting the dioptograph tracings upon which the pictures (figs. 2 and 3) were based was to draw a

line tangential to the inferior margins of the auricular surface and the epiphysis of the anterior superior iliac spine; at the mid-point of this line another line was drawn at an angle of  $30^{\circ}$ . This line came so close to bisecting the auricular surface in all the pelvises (except that of the chimpanzee), and to coinciding with the superior margin of the epiphysis of the anterior inferior iliac spine in the adult Bush female ilium, that it was used as an arbitrary horizontal for all the specimens.

This horizontal conveniently divides the bones into upper and lower moieties and displays how, relative to the chimpanzee, the modern human bones and those of *A. prometheus* have been reduced in height and increased in breadth. Whereas in the chimpanzee the ratio of the supra- to the infra-horizontal height 42:74 gives an index of 176.2, the same ratio in the adult female Bush 61:38 furnished an index of only 62.3. The striking feature in *A. prometheus* is that this ratio, 54:34 (index 62.9), is almost identical with that of the Bush adult and is intermediate between the ratio in the adolescent Bush male, 55:32 (index 58.2), and of the more anthropoidal (i.e. longer-shafted) adolescent female Bantu, 59:45 (index 76.3).

If similarly we divide the horizontal line itself into two parts (anterior and posterior) by a vertical dropped from the anterior margin of the auricular surface, we find that the ratio of these measurements in the chimpanzee, 36:14 (index 39.0), is markedly different from that in the adult female Bush—64:51 (index 79.7)—although the manner of orienting the pelvis affords (by falsely widening the anterior part) the greater advantage in these measurements to the chimpanzee. In this more anthropoidal ratio *A. prometheus* (50:27, index 54) lies closer to the adult female Bush than to the very divergent adolescent female Bantu (53:51, index 96.4) and adolescent male Bush (43:42, index 97.7).

This intermediacy of the *A. prometheus* iliac height measurements between those of the adolescent male Bush and the adolescent female Bantu ilium is, as we have previously had



cause to note, a recurrent phenomenon. Thus the total height of the ilium, 88 mm, is just inside the range of measurements of 87 mm for the Bush and 114 mm for the Bantu bone. The greatest breadth of the iliac crest, 113 mm, is 15 mm more than in the Bush and only 4 mm less than in the Bantu ilium. The length of the shaft of the ilium, 40 mm, is intermediate between that of the Bush (35 mm) and that of the Bantu (50 mm) adolescent ilia. But perhaps the most remarkable fact is that the total iliac area ( $6247 \text{ mm}^2$ ) in *A. prometheus* is intermediate between that of the Bush ( $5603 \text{ mm}^2$ ) and the Bantu ( $7997 \text{ mm}^2$ ) adolescent iliac area.

These projected areas were measured from dioptographic tracings on millimeter paper: the results are set out in the table of measurements. For this comparison I drew a line tangentially to the antero-superior border of the auricular surface and divided up the projected iliac surface thereby into its three main constituent parts, viz.: first, the *auricular* area for articulation with the sacrum; second, the *retro-auricular* area for the attachment of the interosseous and short posterior sacro-iliac ligaments (whose absolute and relative size and strength is of such significance for the preservation of the upright posture); and third, the remainder, or *pre-auricular* area of the sacro-pelvic surface.

Considering these three sacro-pelvic areas seriatim, the *auricular* area in *A. prometheus*,  $252 \text{ mm}^2$ , is almost exactly intermediate between that of the chimpanzee ( $117 \text{ mm}^2$ ) and that of the Bush ( $413 \text{ mm}^2$ ) adolescent ilia. The gap between the adolescent Bush and adult Bush auricular areas ( $224 \text{ mm}^2$ ) is greater than that ( $161 \text{ mm}^2$ ) between the *A. prometheus* and Bush adolescent ilia. The *retro-auricular* area in *A. prometheus* ( $831 \text{ mm}^2$ ) again considerably more than double that in the chimpanzee ( $328 \text{ mm}^2$ ), is somewhat (i.e.  $228 \text{ mm}^2$ ) smaller than that of the Bush ( $1059 \text{ mm}^2$ ) adolescent, but less than half that of the abnormally large Bantu ( $1702 \text{ mm}^2$ ) adolescent ilium. The *pre-auricular* area ( $5164 \text{ mm}^2$ ) constitutes a greater or more "anthropoidal" percentage (82.7) of the total iliac surface than in the Bush adoles-



cent ilium; it is 1033 mm<sup>2</sup> greater in size than in the Bush (4131 mm<sup>2</sup>) adolescent, and only 451 mm<sup>2</sup> less than in the Bantu (5615 mm<sup>2</sup>) adolescent ilium.

One of the most remarkable indications of the robusticity of the bone is afforded by comparing the thickness of the promethean ilium at the middle of the auricular surface (15.5 mm; see fig. 6) with that in the chimpanzee (7 mm), Bush adolescent (10 mm), and Bush adult (14.5 mm); it is only exceeded, and then but slightly, by the massive Bantu adolescent ilium (17 mm). The massive structure of the posterior portion of the iliac blade in *A. prometheus*, coupled with the depth of the greater sciatic notch, indicates not only that the long posterior sacro-iliac and sacro-tuberous ligaments had a typically human form and disposition but that they matched in strength the interosseous or short posterior sacro-iliac ligaments for which so extensive an area of attachment was provided on the ligamentous tuberosity or retro-auricular area of the ilium. The significance of sheer size in the posterior sacro-iliac and sacro-tuberous ligaments does not lie merely in their own improved strength; but also in the added strength thereby symbolized of the ham-strings and more especially of the gluteus maximus, with whose additional attachments these ligaments are so intimately concerned.

The most striking features of the sacro-pelvic surfaces are therefore:

1. the manner in which the *auricular* surface steadily increases in size and becomes more complex in form through the series: chimpanzee, *Australopithecus*, Bush adolescent, and Bush adult.
2. the concurrent progressive increase in the *retro-auricular* surface; save that here the Bantu adolescent shows the largest area — larger even than that of the Bush adult — despite the abnormal size of its articular area.
3. the steady expansion forward, or in breadth, of the *pre-auricular* and *post-auricular* portions of the ilium in the same series; save that here *A. prometheus* exceeds the Bush adolescent.

In regard to the retro-auricular surface it is important to note that in the Bantu specimen the anterior half of the area is occupied by an extensive and highly rugose area which is still further marked by two main corrugations (the more anterior one presumably for the attachment of the ilio-lumbar ligament and the more posterior one for a very strong part of the posterior interosseous ligament). There is nothing in *A. prometheus* or the Bush adolescent (with their smooth surfaces in this region) to correspond with these anteriorly-situated rugosities of the Bantu retro-auricular surface. Even in the Bush adult there is little alteration of this region to suggest the attachment of correspondingly powerful ligaments in this anterior half of the retro-auricular region.

If current textbooks of human anatomy (e.g. Cunningham, 8th ed. and Gray, 27th ed.) are trustworthy in regard to this region, the internal aspect of the cristal epiphysis is the only portion of the iliac bone which serves for the attachment of the muscles of the back (viz. sacro-spinalis and quadratus lumborum), the whole of the retro-auricular area in these adolescent specimens being occupied by the ilio-lumbar and sacro-iliac ligaments. In that event it is patent that the Bantu (and European) human types differ from the Bush type of pelvis in the greater relative development in the Bantu (and European) of the anterior (or ilio-lumbar) half of the interosseous ligament mechanism (*pari passu* with the preservation of the L-shaped or right-angled auricular surface, with its short and long limbs). It is also equally obvious that in these respects *A. prometheus* is closer to the Bantu and European types, and that the massive posterior half of the ilium has a retro-auricular area furnished with a prominent knob-like rugosity equivalent to that of the similarly massive Bantu (see figs. 3 and 6). Meantime the Bush adolescent and Bush adult with their posteriorly slender ilia are somewhat rugose in the central portion of the retro-auricular area but display little tendency whatever towards localized ligamentous strength elsewhere.

Corroborating the facts that the auricular and retro-auricular surfaces of *A. prometheus* are more closely related in form to those of the Bantu (and European) than to those of the Bush race, the table of comparative measurements shows that there is a very close relationship between the ratio of these areas to one another in *A. prometheus* (1:3.1) and the Bush and Bantu adolescents (1:2.9). The chimpanzee in respect of this ratio preserves an intermediate (1:2.8) position between the two extremes provided by the Bush adult type (1:2.3) on the one side and the adolescent Bantu-*Australopithecus* type on the other.

Perhaps the least expected feature of this humanoid ilium is the great size of the pre-auricular area. If it were of anthropoidal shape, this could have been regarded as an anthropoidal feature. The prominence of the anterior superior spine and the narrowness of the "shank" of the ilium may of course, be regarded as anthropoidal stigmata, but the enlarged area and improved forward position afforded by this greatly expanded iliac blade for the shortened iliacus and the anterior abdominal flexor musculature is proof enough of the human and even "ultra-Bush" strength of these components of leg and body build in *A. prometheus*.

We may recall in this connection that the diameter of the acetabular cavity (35 mm) was probably intermediate between that of the chimpanzee (30 mm) and the Bush adolescent (40 mm), while the Bantu adolescent is 50 mm in diameter. The femora were therefore rather slender in structure in *A. prometheus*, as they were also in *Plesianthropus*.

#### THE ISCHIUM

The ischial fragment (see fig. 1) constitutes approximately two-thirds of the right bone. It belonged to a bone which, in contrast with the ilium, was remarkably similar in shape to, but definitely smaller than, the corresponding bone in the

Bush adolescent. The antero-posterior breadth of the bone just above the ischial tuberosity is 20.5 mm. The corresponding measurement in the chimpanzee is 19 mm and in the Bush bone is 26.5 mm. The thickness at the same situation is 12 mm, while in the chimpanzee it is 11 mm and in the Bush bone 16 mm.

These measurements relate the ischium in slenderness to the chimpanzee rather than the Bush type, but its general form is entirely different from that of the living anthropoid. In the chimpanzee, owing to the length of the bone, a distance of at least 12 mm intervenes vertically between the lower margin of the acetabulum and the upper border of the epiphysis of the tuberosity, which is virtually confined to the inferior aspect of this ischial ramus. In the Bush adolescent the tuberosity is so large, and has migrated so far dorsally, laterally and superiorly upon the body of the ischium, that there is approximately 9 mm overlap between the two structures. In *A. prometheus* there has been a similar but less extensive an invasion by the tuberosity of the posterior and lateral aspect of the body of the ischium, with the result that the upper margin of the epiphysis of the tuberosity is situated not more than 5 mm below the acetabular margin.

In the chimpanzee the ischial tuberosity attains a maximal width of 13 mm, in *A. prometheus* of 15.5 mm, and in the Bush adolescent of 18 mm; while in the adult Bush female, after the epiphysis has united, it reached 26 mm. The epiphysis of the tuberosity and the acetabulum are separated from one another both in *A. prometheus* and the Bush adolescent by a groove about 3-4 mm deep and 8 mm wide at its narrowest part. These facts about the ischium corroborate the foregoing deductions, based on the anatomy of the ilium, concerning the presence of a strong and shortened "sacro-tuberous" ligament and therewith a smaller but definitely human gluteus maximus. As in the Bush adolescent, but not in the chimpanzee, there is a strongly developed ischial spine



for the attachment of the sacro-spinous ligament, which was little if at all less powerful than in the Bush pelvis.

The ischial ramus in the chimpanzee is blade-like and triangular in section, having a vertical height of 15 mm and a basal width of 9 mm. In the Bush adolescent it has a more blunted triangular section, being 14 mm high and 9 mm broad. In *A. prometheus* it is even stockier, and in section it forms almost an equilateral triangle, being 12.5 mm high and 10 mm broad.

#### DISCUSSION

From the investigations carried out by various workers (see Sountag, '24) we know that the pelvic musculatures of the anthropoids resemble those of man. In the gluteal region the muscles correspond with one another save that in the orang (and chimpanzee) and additional muscle, the scansorius, arising from the anterior part of the dorsum ilii between the anterior superior spine and the "anterior inferior spine" of the ilium, replaces the tensor fasciae latae of other primates (absent in the orang) and is inserted into the antero-lateral corner of the greater trochanter (as an adjuvant to the gluteus minimus) instead of the fascia lata. Thus it is not the nature of the movements carried out by the lower limb muscles in these several primate creatures that differs, but rather their comparative extent and their efficiency relative to one another.

This question occupied the attention of one of my students, L. G. R. van Dongen, in the preparation of an unpublished thesis ('44), which he presented for the M.Sc. degree in the University of the Witwatersrand, as a result of dissecting the limbs of an infant orang, kindly sent to me long previously by Professor Joseph L. Shellshear (then in Hongkong) from Borneo. Van Dongen discovered for the orang (and the same may be regarded as approximately true for all the anthropoids) that if it be compared on the one hand with *Macaca rhesus* and on the other hand with man, then the order of relative strength is:



		MAN	ORANG	MACAQUE
a.	In the hip joint for			
	adduction	2	1	3
	abduction	3	1	2
	flexion	3	2	1
	extension	3	1	2
	medial rotation	1	2	3
	lateral rotation	1	2	3
b.	In the knee joint for			
	flexion	3	1	2
	extension	1	2	3
	medial rotation	2	1	2 aeq.
	lateral rotation	1	2	3
c.	In the ankle joint for			
	dorsi-flexion	1	2	2 aeq.
	plantar flexion	1	2	3
	inversion	1	2	2 aeq.
	eversion	1	2	3
d.	In the joint between entocuneiform and first metatarsal for			
	adduction	nil	1	2
	abduction	nil	1	1 aeq.
	flexion	nil	2	1
	extension	nil	1	1 aeq.
	opposition	nil	1	2
e.	In the opposition first (hallucial) meta- tarsal phalangeal joint for			
	adduction	1	2	2 aeq.
	abduction	1	1 aeq.	1 aeq.
	flexion	1	3	2
	extension	1	2	2 aeq.
f.	In the first (hallucial) interphalangeal joint for			
	flexion	1	nil	2
	extension	1	nil	2
g.	In the lateral meta- tarsophalangeal joints for			
	flexion	3	1	2
	extension	2	1	1 aeq.
	adduction	2	1	2 aeq.
	abduction	2	1	2 aeq.
h.	In the lateral inter- phalangeal joint for			
	flexion	3	1	2
	extension	1	1 aeq.	1 aeq.

Alternatively expressed, this tabulation indicates:

- (a) that man's superiority in the hip-joints lies, not so much in his power of adducting, abducting, flexing or extending them, but in his capacity for rotating them medially and laterally about the trunk, or alternatively (though van Dongen did not mention this) for rotating his trunk about fixed thighs.
- (b) that man's superiority in the knee joints lies not in flexion or in medial rotation but in maintaining the knees in extension and in rotating them laterally or alternatively for resisting the lateral rotational stresses of the superincumbent weight.

- (c) that in the ankle joints, however, man has a superiority for every class of movement: whether of inverting, everting, or flexing them dorsally (or plantarwards).
- (d) that in the joints between the ento-cuneiform and first metatarsal man has reduced movement in any direction to virtual non-existence; but
- (e) that in the first (or hallucial) metatarso-phalangeal joints he has thereby on the contrary, attained in every class of movement—adducting, abducting, flexing or extending—a superiority corresponding with the superiority he has achieved in all classes of ankle movements.
- (f) that, similarly, in the first (hallucial) interphalangeal joints he has a similar superiority in the only two possible movements, i.e. flexing and extending, but
- (g) that in the lateral metatarso-phalangeal joints, and in
- (h) the lateral interphalangeal joints, he is superseded by the orang and sometimes even by the macaque.

The hip region of *A. prometheus*, as typified by the iliac and ischial fragments, has been transformed to produce joints whose superiority in terms of movement lies, like that of man, in the capacity to rotate the trunk upon the fixed thigh bones, or the lower limbs upon the trunk. Unless the knee joints of *A. prometheus* had been simultaneously modified for improved extension and lateral rotation, and the ankle and the hallucial joints for similar superiorities in stability and movement of the hallux and ankle, corresponding with those of man, the human characteristics of the hip bone of *A. prometheus* would be meaningless.

E. Reynolds ('31) has traced in his valuable paper the modifications of pelvic structure in the direction of producing an iliac blade, or anthropoidal plate as he terms it, when creatures of various mammalian orders adopt habits of bodily erectness. He has pointed out that the principal novelties in the human innominate bone, apart from its becoming broad and short, are the backward bending of the iliac axis

and the development of the cristal tubercle (erroneously termed the "iliac tuberosity"), and the architectural line of strength between it and the acetabulum constituting an additional or 4th axis in the pelvis. He has shown that, during the ventro-dorsal pelvic lengthening and the concomitant backward bending of the iliac axis and promontorial rotation of the pelvis, the tuberosity of the shortened and backwardly bent ischium achieved in man (and consequently also in *Australopithecus*) a posterior position only otherwise obtainable by a long metischial process. Thus in man each innominate bone became transformed into a wheel, with the acetabulum then representing the hub; the 4 pelvic arms or lines of strength, the spokes; while the iliac crest, the pubo-ischiatic ramus, the sacrum, and the ligaments which fill in the gaps may be considered as the rim (Reynolds '31, p. 316).

He goes on to point out (p. 318) that "the backward position of the sacrum and, consequently, of the sacro-sciatic ligaments, gives great power and a direct backward pull to the gluteus maximus, and the position of the origins of the hamstrings on the posterior aspect of the posteriorly-situated ischium gives to these muscles also an advantage towards complete extension of the femur, which is distinctively human."

The mechanics of the human pelvis is highly relevant to our subject but is too extensive a topic for further discussion in this paper and has already been adequately discussed by Reynolds (op. cit). I agree with his contention that "It is the perfect control of lateral balance . . . which gives man the power to stand, walk, and run with his knees and feet close together" (p. 321). I also endorse his claim (p. 310-311) that "Man, and man alone, is able to spring in any direction from a bipedal position, and, moreover, he alights from such a spring with a certainty of balance which enables him to repeat it in the same or a different direction." But I cannot accept his thesis that the development of this power

was "in itself the factor which enabled the ancestral anthropoid finally to abandon the quadrupedal gait, and which freed his fore paws for development into the human hand."

The prime reason for the liberation of man's hands, as Darwin recognized, was their increasing employment in manipulating clubs and missiles. This industrial specialization of the hands in accurate hitting and throwing did not follow but rather provoked the very extensive series of anatomical and physiological changes throughout the body, which enabled lateral springing and every other form of bodily skill perfected by mankind to emerge. It involved primarily the transference of that portion of the body weight which had been borne by the clambering hands and their knuckles (and from the sitting ischia furnished with appropriately purposeful callosities) to the only suitable base for such torsional body work, namely the double columnar mechanism of completely extensible lower limbs and (geometrically speaking) tripod feet linked by extremely powerful ankles.

In unravelling the probable sequence of events in the process of attaining this essentially human achievement of bi-columnar-hexapodal body poise, it is profitable to recall that its sole original purpose was to achieve accuracy in breaking bones, whether with sticks held in the hands or with stones flung from the hands; and that the perpetual purpose behind humanity's collateral or corollary achievements has been turning sticks and stones into better and better tools for breaking bones. Anatomically and physiologically this implies not so much the development of the capacity to leap as that of standing still. Reversing our usual and ontogenetically correct process of looking at the limbs as parts moved from the body we should think in terms of the body and its upper parts being moved from fixed feet.

There is little evidence to show that living anthropoids, lacking bipedal fixity, have achieved any greater degree of accuracy beyond that of other apes in wielding or hurling objects to strike other creatures either in offence or defence; they all rely on their teeth and nails, to which men some-

times revert, rather than things held in their hands, when exerting their bodily strength at close quarters. Consequently the skilled employment of their hands is confined for the most part to manipulative procedures on their own bodies, the care of their young and their companions, and such feeding activities as can be indolently pursued for the most part in the sitting posture. Their capacity for exerting their bodily power in the bipedal position is strictly limited, and is confined to casual breaking and carrying of objects. Man on the contrary makes such consistent and persistent use of his hands and his whole bodily strength in the erect posture that he can use his fists deftly and accurately as weapons, either open as in slapping and cuffing, or closed as in boxing and pounding. But nowhere is man so destitute of intelligence as to be ignorant either of the added effectiveness, both in offence and defense, of objects such as sticks and stones held in the hands, or of the increased advantages, in terms of force and accuracy, of standing still and using the erect posture and the force of gravity in applying the blows.

This accuracy in hitting and hurling, which apes lack but men universally possess in such high degree for it to amount to an inherited instinct, does not necessarily connote a highly developed brain; it demands no greater intelligence than is possessed by human microcephalic idiots with australopithecine cranial capacities (see Keith, '12, p. 108). What it does require is a short and enlarged pelvis rotating on two columns about powerful ankles, above feet that have planted heels and big toes fixed firmly on the ground. With this type of understructure, the trunk can bend laterally or rotate upon the pelvis, as well as flex and extend, while the arms can rotate upon the trunk, and the head flex, extend, bend laterally or rotate upon the neck. All of these upright body movements are required for the performance of accurate hitting and hurling. The relative skill with which these actions are performed in apes and men depends upon the comparative efficiency of brains in co-ordinating with hand and eye movements a series of postural body reflexes which, however complicated, are

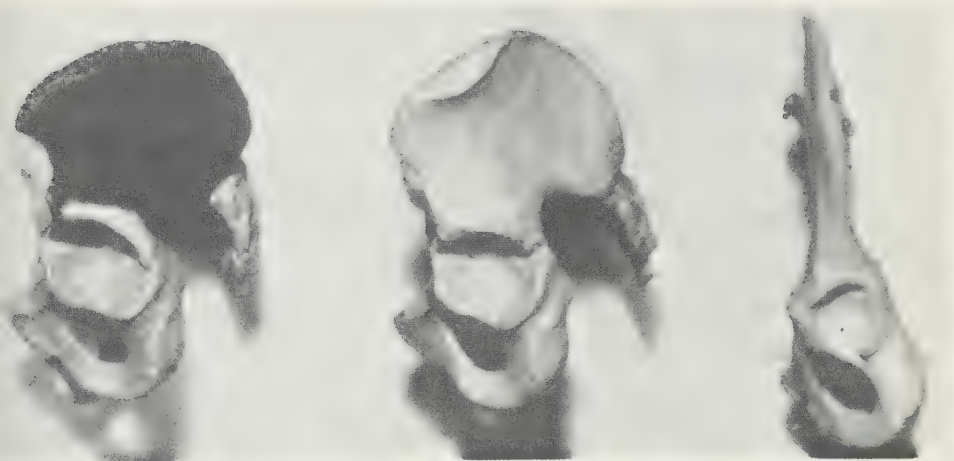


instinctively acquired by all normal human beings during the first year of infancy.

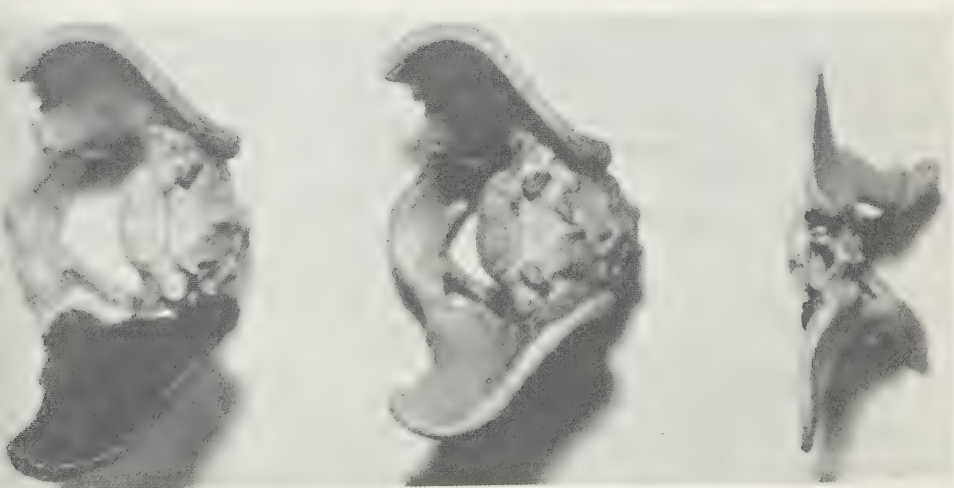
It is now generally conceded that the Australopithecinae were erect ground-living bipeds. I have recently published (this journal, n.s., vol. 7, no. 1) extensive evidence to show that accurate hitting and hurling was also an attribute of australopithecine existence, something regarded in the past as distinctive of mankind. We have noted here that those features of the pelvis which Reynolds ('31) regarded as special to man are duplicated in *A. prometheus*, save only that the tubercle of the iliac crest is not so well developed as it is in living races of mankind. There are, however, as great differences between Bush and Bantu pelvises as between the Bush pelvis and that of *A. prometheus*. In some respects the pelvis of *A. prometheus* is actually intermediate in character between the Bush and the Bantu pelvis. If therefore we rely upon these criteria, and there are no others of which I am aware to bring forward, the pelvis of *A. prometheus* is human, just as its dentition, erect posture, and cranial poise are human. It was a pelvis competent for the discharge in the body of all those functions, physical and physiological, which we associate with the pelvis of mankind.

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7



8

7 Comparative view from the lateral aspect of the left ilium of *Australopithecus prometheus* (reconstructed with a Bush pelvis), cast of a Bush pelvis, and a chimpanzee pelvis, all at approximately the same stage of adolescence. (Orientation in spino-symphysial plane.)  
8 Same as 7, viewed from above (norma verticalis) in the same orientation. Photographs by Dr. J. A. Keen.



THE DIVISION OF ANTHROPOLOGY AND PSYCHOLOGY of the National Research Council announces the formation of a *Committee on Research in Physical Anthropology*, with the following membership: G. T. Bowles (NRC), W. W. Greulich (Stanford U.), W. W. Howells (U. of Wisconsin), F. E. Randall (Climatic Research Lab., Lawrence, Mass.), A. H. Schultz (Johns Hopkins), H. L. Shapiro (Amer. Mus. Nat. Hist.), T. Dale Stewart (U. S. National Mus.), S. L. Washburn (U. of Chicago), W. M. Krogman, Chairman (Grad. School of Medicine, U. of Pa.). It will be the function of this Committee to serve as a clearing-house in all research projects wherein the procedures and technics of Physical Anthropology may be employed; in this sense the Committee is an advisory and consultant body. It hopes that it will be called in at the planning stage of any project wherein it may be employed, in order that there be careful integration of aims and methods from the very start. This notice is an invitation for mutual aid and cooperation. Any suggestions or requests for advice and/or aid may be sent to the Chairman. We solicit and welcome your comments.

THE TERM "RACE" MEANS—a great division of mankind, the members of which, though individually varying, are characterized as a group by a certain combination of morphological and metrical features, principally non-adaptive, which have been derived from their common descent.—E. A. Hooton. *Up from the ape*. The Macmillan Co., New York, 1931, xvi + 626 pp.

—a group of common origin and of stable type.—Franz Boas. Race. Chap. 3 in *General anthropology* (Ed. by Franz Boas), D. C. Heath and Co., New York, 1938, pp. 95–123.

—a group of people who possess the majority of their physical characteristics in common.—Carleton S. Coon. *The races of Europe*. The Macmillan Co., New York, 1939, xvi + 739 pp.

—a persistent strain, within any species, or broadly blood-connected individuals carrying steadily, i.e., hereditarily, more or less of well defined physical characteristics which distinguish them fairly from all other strains or races.—Aleš Hrdlička. The races of man. Chap. 4 in *Scientific aspects of the race problem*. Longmans, Green and Co., New York, 1941, pp. 159–187.

—one of a number of populations which together comprise the species *Homo sapiens* and which individually maintain their differences, physical and cultural, by means of isolating mechanisms such as geographic and social barriers.—M. F. Ashley Montagu. Physical anthropology. In *Medical physics* (Ed. by Otto Glasser), The Yearbook Publishers, Inc., Chicago, 1944, pp. 1014–1031.

## A SECOND ADULT PALATE OF AUSTRALOPITHECUS PROMETHEUS

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### ONE FIGURE

During 1947, at approximately the same time as Mr. James Kitching found the first (occipital) fragment of *Australopithecus prometheus* (Dart, '48), his brother Ben also retrieved a piece of grey breccia from the surface of the dump at the Makapansgat limeworks site. It was put with other promising pieces of breccia but was not developed until after the return of the party to Johannesburg from the second (or 1948) season of work in the Valley. The breccia was then found to contain the right premaxillo-maxillary fragment, which has been depicted by Mr. J. F. Heim in the accompanying text figure.

This second piece of promethean palate is, like the first specimen, probably female and from the right side and also contains the corresponding 4 teeth: the two premolars and the first and second molars. The teeth are in a very advanced state of attrition, however, so the individual was aged, but she had apparently retained her front teeth until her death, because the sockets of the canine and incisors are clearly defined. It is not clear whether the third molar was also then present; that part of the jaw may have been broken away after death because the teeth were seated on a layer of lime which swept up behind the second molar tooth. A badly worn canine tooth in a similar state of fossilisation was also found nearby in the adjacent breccia but does not fit the canine socket present: perhaps it came from the other side. The eroded state of the borders of the bone, where it was frac-

tured medially, posteriorly and superiorly, indicates that the fragment had probably been separated from the rest of the skull for a considerable time before it became fossilised.

The specimen corroborates the anatomical features of the face, nose and palate demonstrated by the cranio-facial fragment previously described (Dart, '49).

Figure 1 displays the fragment from the anterior, inferior, medial and lateral aspects respectively, the mirror image of the right half being indicated in the anterior and inferior views to aid in visualising the appearance which would be presented by a more complete specimen.

The anterior view shows that the nasal gutter was approximately 10 mm wide on either side of the septum and the nasal opening probably attained a width of 25 mm. The socket for the canine root is 25 mm long, for the lateral incisor 12 mm, and for the medial incisor 14 mm; and their respective widths at their openings are 8, 6 and 4 mm approximately. The roof of the elevated palate stands 13 mm above the occlusal plane of the well-worn teeth; and the transverse arch which forms the anterior or premaxillary part of the palate and contains the sockets of these three teeth has the substantial oro-nasal thickness of 15 mm.

The palatal view demonstrates the arcuate outline presented by the tooth series and the advanced attrition of those present; they are worn down to the root canals, and there appears to have been a good deal of osseous recession around one of the roots. There may have been an abscess at the apex of the buccal root of the first premolar (see lateral view). The marked divergence of the molar roots causes the tips of the lingual roots to approach within about 10 mm from the mid-line of the palate. The lingual roots are not separated from one another. The dimensions of the worn teeth, all from the right side, are as follows:

	A-P	TRANSVERSE
First premolar	6	13
Second premolar	8	13
First molar	13	14
Second molar	14	15



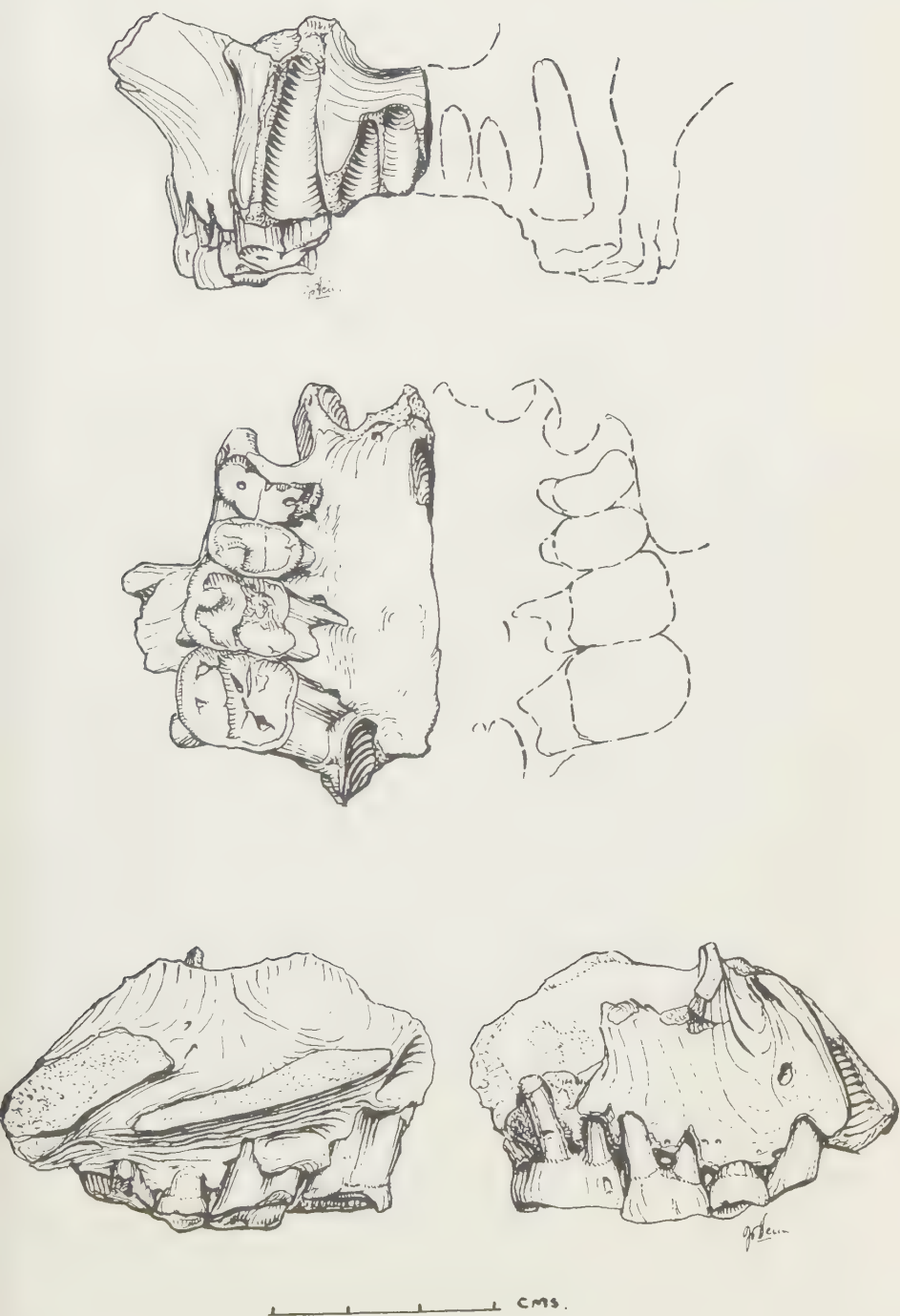


Fig. 1 Drawing of palatal fragment of *Australopithecus prometheus*. Above, facial view; center, palatal view; lower left medial view; lower right, lateral view. Natural size.

They therefore compare very closely with those from the original specimen and present no obvious morphological differences from them.

Antero-medially can be seen the palatal orifice of the incisive canal and posteriorly, near the exposed lingual roots of the second molar, the gutter for the greater palatine vessels and nerves. The medial view expands our knowledge of the promethean type (which was deficient anteriorly and posteriorly to the incisive canal in the previous specimen); because the palate is complete to the mid-line anteriorly and posteriorly to a point opposite the posterior border of the second molar tooth. The palatal process of the maxilla varies from 2 to 5 mm in thickness behind the incisive canal (which has a diameter of 4-6 mm and a palatal opening measuring  $10 \times 6$  mm), and attains a thickness of 8 mm in front of the canal (see fig. 1, medial view, lower left).

The great size and very forward position of the incisive canal indicates the reduction of the premaxillary element in the australopithecine palate (see palatal view). There is scarcely a distance of more than 5 mm intervening between the anterior border of the palatal incisive orifice and the socket of the medial incisor; and a coronal plane through the posterior margin of the canine socket would virtually bisect the orifice of the incisive canal.

The lateral view demonstrates, in contrast to the medial view and the non-bifurcate lingual molar roots, the divergence and distinctness of the buccal molar roots. This view also shows that the zygomatic process of the maxilla arose above the second premolar and first molar as in the previous *A. prometheus* specimen and in *Paranthropus*, and not above the first and second molars as in *Plesianthropus*.

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# THE FONTÉCHEVADE FOSSIL MEN <sup>1</sup>

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EIGHT FIGURES

On August 16, 1947, Mlle. G. Henri-Martin ('47) discovered in prehistoric deposits in Fontéchevade cave (Charente), at depth of 2.60 m, a fossilized human skull vault (Fontéchevade II). Shortly before, at the same level and 3 m away, she had found a small fragment of another skull (Fontéchevade I).

At least 7 m thick, and lying below deposits of the Upper (Magdalenian and Aurignacian) and Middle (Mousterian) Paleolithic, from which it was separated by a stalagmitic layer corresponding to a long phase when the cave was unoccupied, the stratum which yielded the human remains contained a very coarse industry of the "Tayacian" type, of the Lower Paleolithic. Among other species, the fauna is characterized by *Rhinoceros (Dicerorhinus) merckii*, *Dama* sp., *Cuon*, *Testudo graeca*; this is a warm temperate fauna. Archaeology and paleontology therefore agree in placing the date of the level with the human fossils in the last interglacial phase, the Riss-Wurm. This is the first time that fossilized human bones of such an antiquity have been found in France. Their interest springs from the fact that they lay in a bed concerning the stratigraphic position of which there can be no dispute. The stalagmitic layer overlying this bed was absolutely intact when excavation was undertaken, which excludes the hypothesis of any kind of redistribution. The skull cap was 70 cm below this layer (see fig. 2).

<sup>1</sup> Translated by the Editor, who assumes responsibility for all ambiguities, inaccuracies, and other departures from the author's lucid original.

## FONTÉCHEVADE II

This cranial vault comprises practically all of the left parietal, the upper half of the right parietal, and the upper part of the frontal. Some fragmentary material, which cannot be articulated with the rest, belongs to the inferior border



Fig. 1 Localities in France where human remains have been found dating from the Lower or Middle Paleolithic. The group at Les Eyzies designates the Neanderthal finds of La Chapelle-aux-Saints, La Ferrassie, Le Moustier and Pech de l'Aze.

of the right parietal and to the occipital. These pieces are extremely fragile, and thereby distinct from other bones in the deposit, which have instead been hardened by fossilization. This fragility can doubtless be traced to a special reason: the vault had been subjected to the very violent effect of fire, which has left a characteristic imprint on the right side.

The posterior part of the left parietal also displays a hole, with depressed edges, which appears to be the result of a blow received when the bone was still fresh. This fact, together with the absence of other fragments of the same skull or of any part of the rest of the skeleton in the vicinity, weighs against the suggestion of an intentional burial.

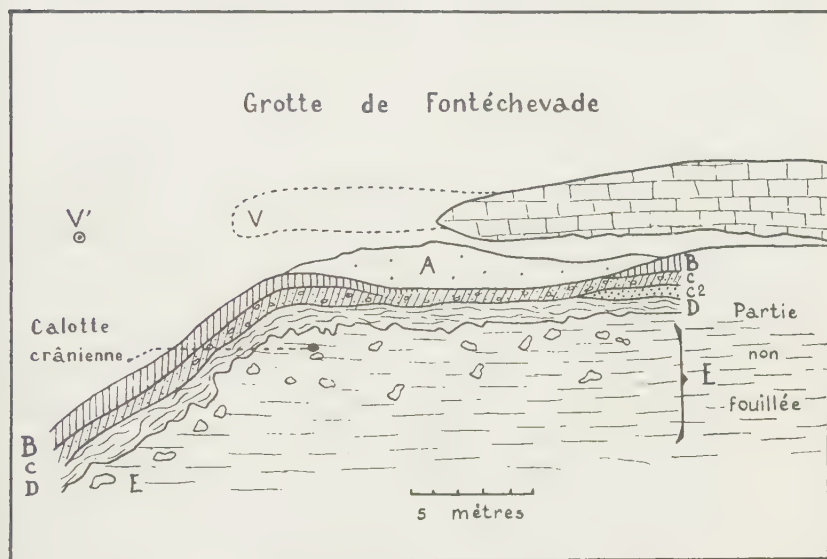


Fig. 2 Semi-schematic section of the Fontéchevade deposits: A, Layers removed in earlier excavations, which contained Magdalenian, Aurignacian and Mousterian industries, thickness 1.30 m. B and C, Loam and argillaceous sand, giving way in the part underlying A to a disturbed area resulting from the cutting down of earlier excavations, thickness 1 to 1.50 m. C<sup>2</sup>, Level with bifaces (Mousterian of Acheulian tradition). D, Stalagmitic floor: thickness, .90 to 1.10 m. E, Tayacian layer; thickness of excavated portion, 7 m. V, Probable extent of the overhang of the vault at the time of the Tayacian occupation. V<sup>2</sup>, Greatest possible extent of vault at time of cave's formation.

When it is examined after restoration and the replacement of broken or displaced fragments, this skull cap appears — contrary to what had been supposed on the basis of examination before preparation — to have dimensions comparable to those of living Europeans. Its form likewise does not immediately exhibit any special features, other than a certain



flattening of the vault and the widening of the posterior parietal region. The thickness of the bones is considerable, reaching 7 to 9 mm according to the place of measurement, surpassing in this respect not only living man but also the majority of the Neanderthals. It is a thickness comparable to that of the Swanscombe skull and, at least as far as fossil European skulls go, exceeded only in the Piltdown cranium.

The sutures are largely obliterated. The coronal suture is united throughout its length, and there is nothing to indicate its position exocranially; however, its direction may be made out from slight traces on the endocranial wall and particularly from radiological examination. The sagittal suture is also united, but is still visible in its posterior moiety. The lambdoid suture and the preserved portion of the temporo-parietal suture are definitely open.

Such a degree of sutural occlusion would indicate, in modern man, an age of 40 to 50 years. This is exceptional in prehistoric men. In all the known Neanderthals, the sutures are still open or only slightly joined (Vallois, '37), and the same is true in the *Sinanthropus* skulls (Weidenreich, '43). The only exception to this rule up to now has been the Piltdown cranium, in which the coronal, sagittal and lambdoid sutures are entirely obliterated. Fontéchevade provides a second exception. Interpretation of this is difficult.

Orientation of the skull was established by using as an arbitrary horizontal, as Keith ('38-'39) suggested for the Swanscombe and Piltdown skulls, the straight part of the vault outline which begins immediately behind bregma and usually ends at the vertex. This horizontal does not coincide exactly with the eye-ear plane; it forms with the latter an angle, open to the rear, which varies according to my own measurements from  $0^{\circ}$  to  $13^{\circ}$ , with the majority of cases falling between  $1^{\circ}$  and  $5^{\circ}$ . In any case, this represents the only possibility of orienting the Fontéchevade fragment, and it has been used in making the frame in figure 4 and in orienting both figure 4 and figure 3.

Seen in the norma verticalis (figs. 3 and 6), the skull presents a pentagonal form with a marked broadening of the posterior part of the parietal region. Toward the front it narrows progressively, but far less than in the Neanderthals:

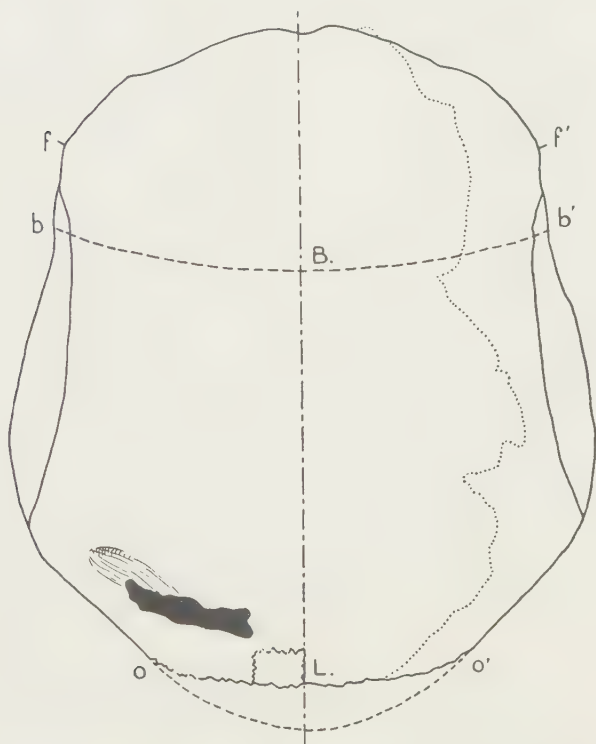


Fig. 3 Fontéchevade II skull, norma verticalis. The contour of the right half has been drawn on the basis of the left, the dotted line marks the limit of what is actually present. One-half natural size. (bBb', general direction of the coronal suture; oo', assumed line of the contour of the occipital; ff', points in front of which the contour becomes approximate only, due to the absence of the lower part of the frontal.

superposition of the norma verticalis of the latter on that of Fontéchevade II shows a very clear difference. Although the region where there might have been a supraorbital torus is missing and, consequently, we cannot be positive as to the presence or absence of this feature, it seems certain that the

constriction which lies behind this projection (post-orbital or post-toral constriction) did not exist in the Fontéchevade skull.

In the *norma lateralis* (figs. 4, 7 and 8) there may be seen the slight degree of curvature in the sagittal outline of the parietal, a curvature which actually becomes evident only in the posterior half of the bone. In the frontal region the curvature is more marked, but the portion of the bone which survives measures only 70 mm, in the median line and on the external surface (80 mm on the internal surface). In the modern French, the length of the sagittal arc of the frontal (nasion to bregma) is on the average 125 mm, with variations from 110 to 145 mm; in the Neanderthals it runs from 115 to 140 mm. That is to say, the missing segment of the Fontéchevade frontal must have been at least 40 mm long, and probably more. If there was a supraorbital torus, it could have been entirely on the missing part. The *norma lateralis* gives us no evidence in the matter.

The *norma frontalis* and the *norma occipitalis* demonstrate that the vault, in transverse section, had somewhat the form of an ogive, or Gothic arch. The occipital view also shows that the maximum width is situated low, and the asterion is placed well outwards, a disposition about which more will be said later.

*Parietal.* Although the left parietal, the more complete of the two, is almost wanting in its inferior border, the presence of isolated fragments of this border on the right side (fig. 4, a. and b) allows this lacuna to be restored, up to a point, and gives an adequate idea of the configuration of the bone.

The superior border (arc bregma-lambda) measures 125 mm, a figure slightly above those for the Neanderthal, Pilt-down and Swanscombe men, but comparable to many modern men, especially dolichocephals, and one which indicates that the vault was long. The sagittal chord of the parietal (chord bregma-lambda) is 115 mm, giving an index of sagittal curvature of 92, a high figure signaling a degree of platycephaly, a general character of primitive men.

The length of the inferior border cannot be exactly determined. It appears, however, that it would hardly have exceeded 100 mm. The bone was therefore much longer above than below, the typical condition in *Homo sapiens* which may also be seen in Swanscombe. In the case of the Neanderthals, Schwalbe wrote that it was the reverse condition which obtained, the bone being longer below. Later investigations have shown that either may occur; it is only among the Prehominids that the lengthened inferior border is found as a constant character. In any case, Fontéchevade Man appears fully evolved from this point of view.

The articular surface for the squama of the temporal has a highly special form. In living man, the squama rises relatively high on the external surface of the parietal, whose corresponding articular face is oriented almost vertically. In Fontéchevade, this surface is less high and much more oblique from the outside inwards (and from above downwards). This disposition, resembling what may be seen in the anthropoid apes, is doubtless partially related to the thickness of the bone. It is also to be found, though less pronounced, in the Piltdown skull. It is still less evident in Swanscombe, and is absent in the Neanderthals who, in this respect, align themselves completely with modern man.

The whole surface of the parietal is extraordinarily unrelieved. The parietal bosses are scarcely distinguished; they coincide with the middle part of the temporal lines instead of being placed low and toward the back as in Neanderthal Man. The temporal lines themselves are entirely effaced, and their position cannot be determined except by the change in the curvature of the bone at this level. This poor definition, which contrasts with what is generally observed in modern man, is a very general character in primitive men: the temporal lines are also almost missing on the Swanscombe skull; they are very little evident on the Neanderthals; it is practically on the Piltdown skull alone that they attain a marked degree. On all these ancient skulls, furthermore — and this feature is also to be seen in Fontéchevade — the temporal lines are



placed low, always at a distance from the median line; the temporal muscles accordingly were little developed in upward extent.

Parietal foramina are absent in the Fontéchevade skull. This absence is certainly a primitive character, since it recurs in Swanscombe and Piltdown, and I have determined that it is very frequent in the Neanderthals, while it is to be seen in modern man on the average in only one case out of three.

Two final characteristics are the presence, on the median plane, of a depressio praelambdaidea comparable to that in Swanscombe, and the existence, at the posterior part of the left parietal, of a rectangular prelambdoid wormian bone, fully united to the parietal.

*Frontal.* More markedly curved than in Neanderthal crania, the Fontéchevade frontal has scarcely visible lateral bosses. Should we perhaps conclude from this that the skull is that of a male? The site of the temporal line is in bad condition and cannot be studied.

As was said above, the lower part of the frontal is missing for a distance of at least 40 mm: the presence endocranially of the upper part of the internal frontal crest indicates however that the broken portion could not have been very extensive. Aside from this, at the lowest point of the frontal on the right side, 13 mm from the median line, the section of the bone reveals a small recession which is the upper extremity of the frontal sinus on this side. This determination is very important, not only because it confirms that this point is not far removed from the nose and the upper border of the orbit, but above all because it gives a point of departure for the eventual reconstruction of the missing part of the bone.

It is known that in all the ancient fossil types — Piltdown Man, the pre-Wurm Preneanderthals of Steinheim and Sacopastore, the Neanderthals proper of the Wurmian — the frontal sinus is always well developed. It is 20 to 30 mm high and occupies, at least in the median line, all the space between the two tables of the bone, the anterior table projecting well forward to form the glabella or the corresponding part of the



torus, and the posterior table bending backward to join with the floor of the vault. Limited in this way, the sinus is so placed that it cannot project much forward of the vertical plane passing through its superior extremity.

The situation of the extremity of the sinus, present in Fontéchevade, shows that this cavity must have had a development comparable to that of the above-mentioned crania. We must endeavor to determine its proper disposition. To

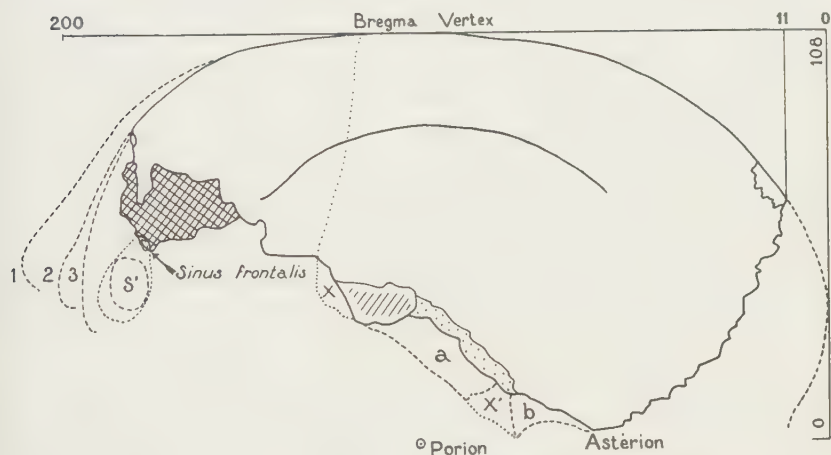


Fig. 4 Fontéchevade II skull, norma lateralis sinistra. The inferior border of the parietal, largely missing, has been completed by using the isolated fragments a and b, which belong to the right side and are drawn reversed; the outlines at x and x' are assumed. One-half natural size. (1, sagittal frontal profile of La Chapelle-aux-Saints; 2, frontal profile of Cro Magnon; 3, frontal profile of Pilt-down II, with S' showing position of frontal sinus of the same; dotted line surrounding the latter is assumed outline of frontal sinus of Fontéchevade II.)

this purpose I have overlaid, on the median profile of this frontal, the median profiles, drawn with a dioptograph, of various frontals of fossil types, with the bregma and the parts of the bone situated in front of that point being exactly superimposed. Figure 4 shows the results.

If the frontals of Neanderthals are used in this fashion, it is apparent that the glabella falls far forward of the vertical passing through the sinus of the Fontéchevade skull, by a

projected distance from the latter which ranges from 26 to 36 mm, according to the specimen used. Even supposing a very large sinus, and a thick wall of compact tissue between this and the anterior surface of the glabella, figure 4 (line 1) shows that the incompatibility is complete.

If we use frontals having a rounder outline and a reduced glabellar projection, such as those of the Cro Magnon or Mechta races (line 2), the separation of the sinus and the glabella is still very considerable. The sinus, when its position is determined by that bit of it which is preserved, falls into agreement only with a straight and almost vertical forehead, such as that of the most fully envolved *Homo sapiens*. It is interesting to note that the frontal referred to Piltdown II completely fills these conditions (line 3): if the profile of its uppermost extremity is superimposed on the end of the Fontéchevade frontal, not only does the sinus of the Tayacian individual correspond perfectly to the piece thus added, but the sinus of Piltdown II also falls at the very place assumed for the other (fig. 4, S').

Agreeing with what might have been presumed from examination of the various skulls in the norma verticalis, reconstruction of the frontal of the Fontéchevade Man therefore confirms this important fact: he had a forehead constructed on the same type as our own, and totally devoid of the torus so characteristic of the Neanderthals.

*General dimensions.* Only three diameters can be estimated with a satisfactory degree of precision. All three are transverse, and are obtained by doubling measurements taken on the left half of the skull. These are: the maximum transverse diameter; the bi-stephanic diameter (taken in lieu of the maximum frontal diameter, the procuring of which is hindered by the absence of the lower part of the frontal); and the bi-asterionic diameter. Their values, respectively, are 154, 122, and 126 mm.

These three figures are high. The maximum width is superior to that of the known Neanderthals, the sole exceptions being La Chapelle-aux-Saints and La Ferrassie, these being

distinguished by their very large dimensions in general. It surpasses that of the Swanscombe skull (142 mm) but, curiously enough, is identical with that attributed to the Piltdown skull by Keith in his reconstruction of 1938-39.

The bi-asterionic diameter merits special attention. It also is remarkably high. Almost as great a figure (123.5 mm), however, was given by Morant ('38) for the Swanscombe skull, and this author noted that it surpassed many of the figures (average and individual) obtained by him for a series of recent English. But the widening of the bi-asterionic diameter is not peculiar to Swanscombe. It is to be seen in the majority of Neanderthals. It occurs also in Piltdown and, according to Battaglia ('48), in the Quinzano skull (124 mm). In all living men, whether dolichocephals or brachycephals, the bi-asterionic diameter is on the contrary much less, and in the men of the Upper Paleolithic as well. A high figure, indicating a marked transverse development of the occipital, should therefore be considered a characteristic of the people of the Lower Paleolithic.

In order to compare the degree of development here with that of the rest of the skull, I have made use of two indices: the first gives the bi-asterionic diameter in relation to the maximum transverse diameter (transverse parieto-occipital index of the literature), and the second gives the bi-asterionic diameter in relation to the bi-stephanic (I term this the stephano-occipital index). When calculated on a number of series of modern French, some dolichocephalic and some brachycephalic, the mean of the parieto-occipital index varies between 76.3 (a series of Bretons, brachycephalic) and 79.1 (a series of Basques, mesocephalic). It is always below 80. This index is very much higher in the Neanderthals, as well as in Piltdown, Swanscombe and Fontéchevade. The same high figures are to be seen in the Prehominids: 89 in *Pithecanthropus* II, while the mean of 5 *Sinanthropus* skulls is 81.7, with individuals running from 78 to 86.7 (Weidenreich, '43).

The stephano-occipital index gives similar results. In my series of French, the means vary from 90.8 (Bretons, brachy-

cephalic) to 96.7 (Corsicans, dolichocephalic). The two individuals from Cro Magnon have similar values: 86.6 and 91.5. On the contrary, the index exceeds 100 in the Neanderthals and in Fontéchevade.

	BI-ASTERIONIC DIAMETER	PARIETO-OCCIPITAL INDEX	STEPHANO-OCCIPITAL INDEX
La Ferrassie (Vallois)	(136)	86	111.9
Piltdown (Keith, '38-'39)	(130)	84.4	..
La Chapelle-aux-Saints (Vallois)	127	81.4	104
Fontéchevade (Vallois)	(126)	81.8	103.2
Swanscombe (Morant, '38)	123.5	87	..
77 Parisians, male (Vallois)	112.4	77.4	92.4
Means of various recent series	..	76.3-79.1	90.6-96.7

Length and height of the Fontéchevade skull cannot be estimated by direct means. It is possible, however, to arrive at some approximate figures.

The distance from lambda to the most anterior point available on the midline of the vault is 173 mm. The maximum length is therefore greater than this figure. Now, an examination of the vault in the *norma verticalis* (fig. 3), giving consideration to the direction taken by the posterior parts of the parietals, makes it possible to form an estimate of the probable contour of the occipital: with an outline such as that added to figure 3, the projection of the occiput behind lambda should be 10 to 12 mm. Carrying this projection over onto the *norma lateralis* (fig. 4) gives an occipital whose form accords with the general aspect of the skull and cannot be very far from actuality, at least if the bone was not formed "en chignon," which does not appear to be the case. With the posterior part of the skull determined in this way, the length becomes 191 mm.

We have seen, furthermore, that the position of the frontal sinus calls for a vertical forehead, like that which has been assumed in figure 4; with this the length becomes 195 mm. We may take this figure as a probable one. In any case, it is more likely to be below rather than above the true figure,



since a less projecting occiput or a less vertical profile for the forehead are out of the question.

Although inferior to that of most of the Neanderthals, this length exceeds that suggested by Morant for Swanscombe (181.5), but nearly coincides, as was the case with the width, with that adopted by Keith for Piltdown: 194 mm.

The height seems more difficult to estimate. We may start with the fact that, when a skull is oriented on the eye-ear plane, the porion is on the average 5 mm below the level of the asterion, with the variations being almost entirely between 3 and 10 mm, with extremes at 0 and 10 mm; Neanderthal crania agree in this respect with those of recent man. The distance of the asterion from the bregma-vertex plane is 104 mm in Fontéchevade. The distance of porion from this plane may therefore be estimated at 109 mm. But we have seen that the bregma-vertex plane is slightly oblique relative to the eye-ear plane and, furthermore, the porion-bregma distance does not run exactly vertical; we may therefore reduce the latter to 108 mm, taking 104 and 112 as the limits of possible variation.

The above facts allow us to calculate three indices:

Length-breadth index	78.9 ??
Length-height (porion) index	55.3 ??
Breadth-height (porion) index	70.1 ??

The length-breadth index rates as high mesocephaly. It may be too high, since the length assumed here, 195 mm, is the minimum. It does not seem, however, that the skull could have been dolichocephalic. The length-height and breadth-height indices fall in the categories of chamaecrany and tapeinocrany respectively; they indicate a very low vault.

The likeness of the above indices to those determined for the Piltdown and Swanscombe skulls is interesting:

INDEX	FONTÉCHEVADE	PILTDOWN (Keith, '38-'39)	SWANSCOMBE (Morant, '38)
Length-breadth	78.9	79.4	78.2
Length-height	55.3	56.7	..
Breadth-height	70.1	71.4	..



Comparison with recent crania, on the other hand, reveals certain differences. In general, the latter are more dolichocephalic, with lower height-length indices and higher height-breadth indices; the architecture of the cerebral cranium is not the same.

For an estimate of the capacity, I have used the Lee-Pearson formula, subtracting 50 cm<sup>3</sup> from the figure obtained, following Wacker's advice for thick-walled skulls. Given the thickness of the Fontéchevade skull, such an amount is certainly a minimum. The capacity calculated in this way is 1,470 cm<sup>3</sup> if the skull is male, and 1,460 cm<sup>3</sup> if it is female. These are high figures. They hardly vary if the porion is assumed to be higher or lower: with a porion-bregma diameter of 104, we get 1,425 cm<sup>3</sup> (male) or 1,415 cm<sup>3</sup> (female); with a diameter of 110, we get 1,495 cm<sup>3</sup> and 1,485 cm<sup>3</sup> respectively. In any case, and as a consequence of its great breadth, the Fontéchevade skull is voluminous. There can be no doubt that in this it was like Swanscombe and Piltdown.

#### FONTÉCHEVADE I

This is represented only by a piece of the frontal 5.5 cm high and 4 cm wide, but it has great interest in that it comprises the region of the glabella and the left supraorbital ridge, with the internal orbital process of the same side and a small part of the overlying roof. Its general appearance and its thickness, being inferior to the skull cap already described, show that it derives from another individual; this one was also adult.

The essential fact is the absolute absence of supraorbital torus: the glabella and the brow ridge are less developed than in the Upper Paleolithic Europeans, or even the majority of Europeans of today. They recall, in their general configuration, skulls of female Europeans; there is no nasion depression, and the brow ridge does not extend down to the upper border of the orbit.

This feeble development, differing from what may be observed in the Neanderthals, on the other hand suggests in

every way the frontal of Piltdown II: diagraphic tracings of the anterior outlines of the two bones almost coincide. But while the Piltdown II frontal is extraordinarily thick, showing its intimate relationship to Piltdown I, that of Fontéchevade I is no thicker than in modern man, which differentiates it from Fontéchevade II as well: the thickness of the bone a little above the brow ridge, and 2 cm from the median line, is 4 mm in Fontéchevade I, as against 8 mm in Piltdown II.

#### DISCUSSION

The preceding description shows that, in spite of the defective condition of the Fontéchevade braincase and its large lacunae, a study of it allows certain conclusions. They may be summarized thus:

*Skull very thick, with a pentagonal form and a low vault; mesocranial and doubtless also chamaecranial and tapeino-cranial. Bi-asterionic width pronounced, both absolutely and relatively. Parietal of the type of Homo sapiens, but with very subdued relief, absence of parietal foramina, and primitive disposition of the temporo-parietal articular areas. Forehead vertical and devoid of a torus. Cranial capacity probably large.*

Comparison with *Homo neanderthalensis* shows numerous differences. They have been listed in due succession in the description above; the form of the forehead, and especially the absence of a torus, establishes a categorical distinction at one stroke. This distinction is equally valid vis-à-vis the contemporary Preneanderthals—this is to say, the Saccopastore specimens, belonging like Fontéchevade to the Riss-Wurm, and the Steinheim skull, of the same phase or even the Riss. It is similarly valid vis-à-vis the Neanderthaloids of the Riss-Wurm in Palestine, whose systematic position is undecided: Galilee, Mount Carmel and Kafzeh. All these fossil men possess a marked frontal torus. This Fontéchevade Man lacked.

Does a forehead without a torus oblige us to accept Fontéchevade as *Homo sapiens*? This conclusion would also be

unwarranted, since our Tayacian man furnishes a series of characters classifying him as primitive: great thickness of bone, platycephaly, lack of definition of the bone surface, absence of parietal foramina, marked bi-asterionic width. While some of these characters recur in Neanderthal Man, taken together they are significant particularly of the Piltdown-Swanscombe group: the thickness of the Fontéchevade skull is identical with that of Swanscombe, in which the curve of the parietal is nearly the same; the form of the temporo-parietal articulation recalls that in Piltdown; the length-breadth and the height indices are almost the same as those of the latter skull and the form of the frontal provides a curious identity. Such an identity between Piltdown and Fontéchevade even extends to the occlusion of the sutures of the skull, otherwise an exceptional condition in Paleolithic man.

As far as we may take a stand, considering the incomplete state of the available crania, it is accordingly with the men of Piltdown and Swanscombe, and in their area of taxonomic significance, that we should range Fontéchevade Man. Perhaps it will be necessary to place within the same group the man of Quinzano, very recently (1948) published and represented by an occipital fragment marked by two of the characters pointed out above: great thickness of the bone and great bi-asterionic width. But the assigning of this fossil to the Lower Paleolithic is not absolutely reliable. In any case, the affinities already discussed allow us to open afresh the question of the origin of *Homo sapiens* and of the genetic relationship between the latter and *Homo neanderthalensis*.

(a) It is now known that the family Hominidae essentially comprehends three great groups: the Prehominids, who should be granted the status of a genus (*Pithecanthropus*), represented by at least 4 different forms (*P. erectus*, *P. robustus*, *Meganthropus*, *Sinanthropus*), and dating from the Lower and perhaps also the Middle Pleistocene; *Homo neanderthalensis*, who has the status of a species and whose numerous representatives are spread out over the final part of

the Riss-Wurm and the first half of the Wurmian, with perhaps a late survival in Rhodesian Man; finally, *Homo sapiens*, who appeared toward the end of the Wurmian with races differing little from those of the present day.

From the first group to Neanderthal Man, and then from the latter to *Homo sapiens*, we witness a progressive evolution in various characters, particularly the expansion of the neurocranium and the reduction of the splanchnocranium and the teeth. Many writers have concluded from this that *Homo sapiens*, who appeared in European deposits at the very

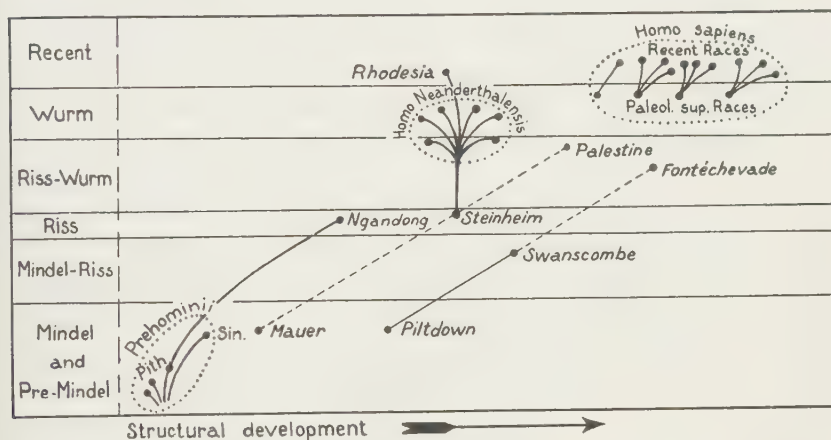


Fig. 5 Position of the principal fossil Hominidae relative to their geological ages and their morphological evolution. No account has been taken of the actual relative length of the several geological periods.

moment when Neanderthal Man was disappearing, arose as a transformation of the latter. Sustained by Huxley, Fraipont, Kollmann, Verneau, Weinert, etc., and long a classic, this theory has recently been energetically defended by Hrdlička, modified to the extent that he did not consider Neanderthal Man to be a distinct species but rather an "evolutionary phase" of the genus *Homo*. Weidenreich, in all his own works, expanded the same thesis broadly.

(b) Certain authors, however, particularly M. Boule ('11-'13), pointed out that the typical Neanderthals—those of the



Wurmian—had much too specialized a structure to have given rise to the fossil men who came after them. In western Europe, these writers added, prehistoric deposits show a very clear cleavage between the Upper and the Middle Paleolithic; the Mousterian industry and Neanderthal Man disappeared simultaneously and then, with no transition, the Aurignacian industry appeared together with a sapiens type of man already fully differentiated.

Study of the men of Saccopastore and Steinheim, on the other hand, seems to show that, as one goes back in time, the most distinctive features of the Neanderthals become attenuated; the hypothesis has accordingly been put forth that *Homo sapiens* may be traced to ancient forms, still only slightly specialized, of the Preneanderthal phylum. The fact that the men of Palestine exhibit characteristics intermediate to those of Neanderthal and Cro Magnon at the same time suggested that the transition, vainly sought in Europe until then, had taken place in the Near East.

(c) From time to time, however, notice has been drawn to the discovery of fossil men much older than the Neanderthals but exhibiting nevertheless all the features of *Homo sapiens*, which would seem to indicate that the latter must have had a much older origin, going back perhaps to the base of the Quaternary: the finds at Denise (1884–1859), Castenodolo (1860–1889), Moulin-Quignon (1863), Olmo (1863), Clichy and Grenelle (1867–68), Galley Hill (1888), Ipswich (1912) and London (1925), to cite only the European examples.

Critical study of all these remnants and the conditions under which they were found shows that it is necessary to discard them once and for all. Although strenuous efforts are made periodically to return them to currency for the support they provide for certain theories which are more philosophical or sentimental than scientific, they will not stand up under impartial examination. The nature of the deposit bearing the Denise specimens cannot be verified, but it was determined, a short while ago, that even the bones which were certainly indigenous to the deposit were not fossilized; the



Castenodolo men came from recent burials; the Moulin-Quignon jaw is modern and was fraudulently introduced; the skeletons of Clichy and Grenelle cannot be precisely dated but are very probably recent, since they likewise are not fossilized; the Ipswich and London skulls probably belong to the Upper Paleolithic, and this perhaps applies also to the Olmo skull, which was found under conditions which lend themselves to discussion; recent researches (1948; see Montagu and Oakley, elsewhere in this issue) have finally shown that the Galley Hill skeleton was a burial.

(d) If the preceding cases must be eliminated, and if as a consequence the argument for the antiquity of *Homo sapiens* as such has no reliable basis, the probability of his origin as derived from non-Neanderthal forms does not therefore necessarily have to be rejected. The Piltdown discovery (1912), apprising us of the existence during a very remote phase of the Quaternary of men whose neurocranium approximated that of modern man's, had suggested this possibility as long ago as that. The Swanscombe skull (1935), which some would relate to the Preneanderthal Steinheim, but which instead, as Keith has shown, recalls Piltdown, argues the same idea. Unfortunately we are still dealing with remains whose stratigraphical documentation is imperfect. Both of them were included in alluvial terraces of disputed age, which might have undergone redeposition. The Piltdown deposit contained a mixture of fossils of various periods, injecting so much discussion into the interpretation of the jaw and the braincase, and of their mutual relationships, that certain writers have refused to grant these remains any paleontological significance at all!

The interest of the Fontéchevade discovery is that it clarifies the problem. In contrast to earlier finds of human remains we have here, in effect, a specimen which is well dated and found in a stratigraphic context which allows of no dispute: *this is the first time that man, certainly not Neanderthal although earlier than the Neanderthals, has been found in Europe under such conditions.* Now this type, as we have

seen, taking all its characters together, aligns itself with the Piltdown-Swanscombe forms. This confirms in turn the correctness of associating these two fossils themselves. And above all, it provides definite proof of the existence, parallel to the Neanderthal phylum but independent of it, of a human line of development with an upright forehead lacking in a torus.

It would be inexact to say that this second phylum belongs to *Homo sapiens*, since we know that Piltdown Man had an extremely primitive mandible, and also that Fontéchevade Man was not identical with man of today. As long as we lack more complete specimens, uncertainty will hold sway regarding the exact taxonomic position of all these fossils. Be that as it may, the essential fact is this: the second phylum supplies the road which led at last to *Homo sapiens*. The changes which it would have had to experience to give rise to the latter are actually much less than those the Neanderthals would have had to undergo.

Must we then exclude the last completely from our own lineage? In so far as this concerns the Neanderthals *sensu stricto*, the answer must be affirmative. Too many arguments, anatomical, stratigraphical and archaeological, array themselves against the thesis defended by Hrdlička and Weidenreich to allow it validity.<sup>2</sup> If, however, we turn to the Preneanderthals (see fig. 5), the question becomes different. Might it be that some of the latter gave rise to certain of *Homo sapiens*, with the Piltdown-Fontéchevade line supplying others? We lack the evidence to answer this. We know that any such transition did not take place in Europe, because the first of the two phyla named disappeared from Europe during the Wurmian, and the second before this phase. Now,

<sup>2</sup>In one of his last publications F. Weidenreich, criticizing an article in which I noted ('46) that many fossil types of man must have been the ends of evolutionary branches and became extinct without descendants, wrote ('49, p. 156): "If Neanderthal Man, for example, was not the ancestor of modern man, who was this ancestor? Vallois takes the easier way out and does not dwell on this important point." The Piltdown and Swanscombe men had been known for a long time when Weidenreich wrote this passage! But the Fontéchevade discovery is the real answer to his criticism.

the only fossil men outside of Europe who can give us any information are the Neanderthaloids of Palestine: do they represent a transitional stage between the Preneanderthals and the Cro Magnons, or are they the result of a mixture between Neanderthals and non-Neanderthals? On the answer to this still unresolved question depends one's judgement as to whether the Preneanderthal phylum has carried on into our own day.

Weidenreich, furthermore, has shown that the Ngandong men, found in Java in deposits approximately contemporaneous with the Riss-Wurm, should be taken as the direct descendants of Pithecanthropus. A third human phylum would therefore have existed in Indonesia. Weidenreich considers that it extended upwards to Wadjak Man and, through him as an intermediate stage, to the Australians. No anthropological proof, outside of the common geographical location of all these forms, has as yet been furnished to support this opinion, which is echoed by many anthropologists but which as yet cannot be considered as more than a hypothesis. Far from originating in Java, may not the Australians have come from southern Asia? However, if Weidenreich's thesis is one day substantiated, it will be necessary to conclude that this third phylum also ended at the stage of *Homo sapiens*.

These conclusions show that the origin of our species is much more complex than was formerly believed. Evolving according to the principle of "adaptive radiation," the family Hominidae doubtless rapidly produced several phyla which evolved in parallel, giving out branches of which certain ones became extinct more or less quickly, with others continuing their progress. Several of them, perhaps, contributed to the formation of *Homo sapiens*, whose races would therefore have a much more ancient origin than is generally supposed. The classic idea that the Hominidae may be ranged in a single phylum which, passing through Neanderthal Man, ends at man of today—that man, in other words, is the result of a simple linear evolution, should be abandoned from every point of view.

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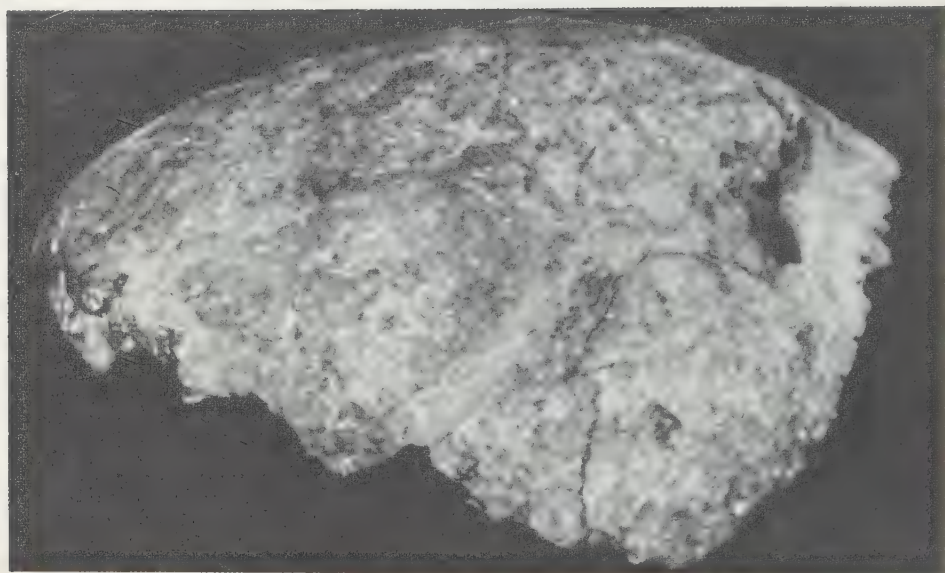
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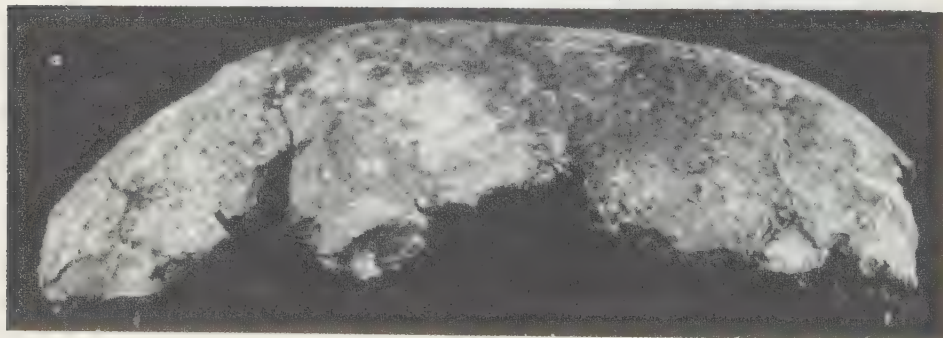


6 Fontéchevade II skull, in norma verticalis. The white lines indicate the position of the midline of the vault. Two-thirds natural size.





7 Fontéchevade II skull, in norma lateralis sinistra. Two-thirds natural size.



8 Fontéchevade II skull, in norma lateralis dextra. Two-thirds natural size.

# THE ANTIQUITY OF GALLEY HILL MAN

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SIX FIGURES

## HISTORY OF INQUIRY

Galley Hill, in the parish of Swanscombe, Kent, forms the brow of the 100-ft. terrace on the south side of the Thames. The famous skull and associated bones were found by a workman in 1888 when the gravels which cap the terrace were being removed to uncover the underlying chalk for quarrying on the north side of the hill. Matthew Heys, headmaster of the village school adjoining the pit, was shown the bones protruding from the gravels 8 feet below the surface shortly after they had been exposed. School duties prevented Heys from taking any immediate action himself, and it so happened that an amateur archaeologist, Robert Elliott, later visited the pit and took possession of the bones. He intended to describe them, but was unable to find the necessary leisure, and 8 years later placed them in the hands of E. T. Newton of the Geological Survey.

In 1895 Newton published an account of the skeleton and of the evidence for its antiquity. He pointed out that the skull appeared to represent an extreme form of the Long Barrow race (typically Neolithic), but as he could find no reason for doubting the statements of Heys and Elliott that the gravels overlying the bones were undisturbed, he concluded that the remains were Paleolithic.

If the geological evidence had indicated an *Upper* Paleolithic age there would have been less scepticism about Newton's claim. In fact Klaatsch ('10) compared the skull with the Combe Capelle type, and tried to make out a case for the Galley Hill gravel being of similar age (Aurignacian). But the Early Paleolithic age of these deposits was well established, and up to a decade ago few anthropologists were ready to find *Homo sapiens* antedating Neanderthal Man. In 1935-36, however, Mr. A. T. Marston discovered part of a human cranium at a depth of 24 feet in the 100-ft. terrace gravels at Swanscombe. There could be no doubt that this was a fossil skull of Early Paleolithic (Acheulian) age. When Le Gros Clark and Morant demonstrated that so far as it was preserved it showed no features distinguishing it from *Homo sapiens*, interest in the Galley Hill find was naturally revived. All those who were dependent on published evidence alone now inclined to accept the Galley Hill skeleton, provisionally at any rate, as Early Paleolithic (Coon, '39, p. 2; Montagu, '45, p. 101; Hooton, '47, p. 365). Authorities at the British Museum (Natural History), familiar with the material, remained doubtful.

Interest in determining the relative antiquity of bones by mineral analysis led one of the present authors (K.P.O.) to re-investigate the Galley Hill evidence. During the summer of 1948 some minute samples of the skeleton preserved in the Robert Elliott Collection at the British Museum (Natural History) were submitted to the Department of the Government Chemist, London, for fluorine-analysis, following the suggestion made at a meeting of the British Association in September 1947 (Oakley, '48).

In the summer of the same year the other author (M.F.A.M.) visited England on a grant from the Viking Fund which enabled him to undertake field studies in the Galley Hill-Swanscombe region. While in London he took the opportunity of making a thorough examination of the Galley Hill skeleton, in which he had long been interested. When the authors met at mid-summer they found that they had independently reached

similar conclusions with regard to the probable dating of the skeleton, and at the request of the Keeper of Geology, British Museum (Natural History), they prepared a joint report on their findings (Oakley and Montagu, '49). The present paper summarizes their conclusions. It should be set on record that those based on morphology (M.F.A.M.) were reached before the results of the fluorine test became available.

#### GEOLOGICAL EVIDENCE

The gravels at Galley Hill are part of a dissected sheet of gravels and sands, and were originally continuous with those exposed in the Barnfield pit, in which the Swanscombe remains were discovered, half a mile southwest. These 100-ft. terrace deposits reach a maximum thickness of 40 feet at Barnfield, and lie in a broad asymmetric channel trending west-east. The Galley Hill chalk pit is situated at the northern margin of this channel. Thus, on the south side of the pit, where the skeleton was found, 10 feet of fluviatile sandy gravel rests on the Chalk (fig. 1); but on the north side there is no vestige of fluviatile deposits, the chalk being capped by about 5 feet of solifluxion gravel and loam, strongly festooned.

It appears from the accounts of the discovery given by Elliott (Newton, 1895, p. 518) and by Heys (Keith, '29, pp. 254-256), that the skeleton was embedded mainly in a horizontal seam of loam, but that the bones projected down into the underlying bed of sandy gravel, which was about two feet thick and rested directly on the chalk. It has been assumed by a number of writers (Rutot, '10; Keith, '29) that the seam of loam and the underlying basal gravel corresponded to the Lower Loam and Lower Gravel of the standard or Barnfield pit sequence of Swanscombe 100-ft. terrace deposits (Dines, '38). The Barnfield Lower Loam is sterile, but the Lower Gravel yields an abundant Clactonian industry and is devoid of Acheulian hand-axes, which are characteristic of the Middle Gravels. On the evidence of the implements collected by Elliott, which are almost exclusively hand-axes, the gravels



and interstratified sand and loam of the Galley Hill pit were wholly of the Middle Gravels stage.

Thus if the Galley Hill skeleton were indigenous to the bed in which it lay it could be assumed to be of Acheulian age, but there are a number of considerations which indicate that it was *not* indigenous.

Considering the rarity of even the most fragmentary remains of man in Pleistocene river deposits, the finding of what was evidently a nearly complete skeleton in a river terrace of Early Paleolithic age suggests that it was introduced by later burial. This is supported by the fact that although large amounts of gravel have been removed from the pit no fossil animal bones have even been recorded there. The equivalent deposits in the Barnfield pit on the other hand have yielded quantities of fragmentary fossil bones and teeth. Our excavations at Barnfield pit and Galley Hill showed the reason for this difference. Whereas the Barnfield gravels and sands and loams are capped by clayey deposits and have escaped decalcification by percolating water, those in the Galley Hill pit are completely decalcified. This evidence alone almost amounts to proof that the skeleton was buried in the Early Paleolithic deposits after they had been decalcified.

Various authors have admitted the probability that the Galley Hill skeleton was an artificial interment, but have maintained that burial took place from a "Chellean" or Acheulian land-surface, on the grounds that Elliott and Heys stated that the overlying gravel appeared to be undisturbed, and that graves are rarely if ever as deep as 8 feet. However, by the time that those observers saw the bones much of any evidence of burial would have been destroyed by the gravel digger. Moreover, examination of the Galley Hill sections leads us to believe that disturbance in the gravels would have been difficult to detect (fig. 3). It is possible that the uppermost layers were not fluvial gravels but solifluxion gravels of late Pleistocene date. This leaves the possibility that the skeleton was buried from a late Pleistocene surface. However, once the Galley Hill skeleton is admitted to be a burial there



is nothing in the recorded evidence by which it can be dated. It could belong to any period subsequent to the formation of the bed in which it was buried.

#### FLUORINE TEST

By analyzing a large number of specimens from several geological horizons, and averaging the results, it can be shown that the fluorine content of bones increases with geological age (Carnot, 1893; see also Middleton, 1844). The reason for this is that hydroxyapatite, which is a major constituent of bones and teeth, acts as a natural trap for the wandering fluorine ions that are present in at least small quantities in most ground waters. The fluorine becomes fixed in the apatite lattice, the ultramicroscopic crystal units of hydroxyapatite being converted one by one into fluorapatite. This is a very stable mineral, resistant to weathering, and consequently once fluorine has entered bone it is not readily leached (except under conditions which would destroy the whole bone). Thus with the passage of time the proportion of fluorine in fossil bone increases. On account of the porosity of bone, the F-fixation is not confined to the surface of a specimen, but affects the whole body of the material.

So many variables are involved that it is of course quite impossible to estimate the geological age of a bone merely by determining its fluorine content. For example, Pleistocene bones in a fluorine-rich region may have accumulated as much as Eocene bones preserved in an area of fluorine deficiency. Nevertheless, if one is dealing with two groups of bones preserved under similar conditions in the same area it is sometimes possible to determine whether one is significantly younger than the other by comparing their fluorine contents. This "fluorine test" has an obvious application where human remains have been found in a Pleistocene deposit and where it is doubtful whether they are indigenous or have been introduced by later interment. The possibilities of the test are at present being investigated in England (Oakley, '48). The results obtained so far indicate that, except in regions of

extreme fluorine abundance (*e.g.* volcanic areas), the test is reliable for determining the relative antiquity of bones from a given area so long as they are contained by permeable matrices. It is thus quite applicable to the Galley Hill problem, for Swanscombe is not a fluorine-rich region, and there is no doubt that the skeleton was embedded partly in gravelly sand, partly in loam.<sup>1</sup>

The 5 samples of the Galley Hill skeleton preserved in the British Museum were submitted to the Department of the Government Chemist, together with samples of 22 bones from various loams and gravels in the Swanscombe region. Mr. R. H. Settle and his colleagues Dr. C. R. Hoskins and Mr. E. C. W. Maycock determined the fluorine content of these samples, using a method which is volumetric for the higher proportions of fluorine, and colorimetric for the lower ones. (The analytical procedure adopted, which is a modification of the

<sup>1</sup> It so happens that Elliott preserved samples of the deposits in which the Galley Hill remains were found. These samples, collected at different times, were placed in two boxes which were eventually deposited in the Department of Geology, British Museum (Natural History). One of these contains coarse reddish-yellow quartz sand with numerous small flint pebbles mostly less than 10 mm in diameter. The lime content and clay fraction of this sample are negligible. A manuscript label contained in the box signed "R. Elliott" bears the following inscription "Sample of Gravel in which I found the Remains at Galley Hill—2 ft. from Bull Head of Chalk." (The Bull-head refers to a band of large flint nodules, partly embedded in the Chalk.)

The second box contains lumps of hard loam of pale reddish-brown color. The manuscript label reads: "Clay from Galley Hill: Dug out by the late Mr. Topley, Mr. Newton, Dr. Corner, and myself, June 12th, 1894. R. Elliott." A note in the corner of the label reads: "3 ft. B. H." (presumably 3 feet above Bull Head). This sample was evidently regarded as identical with the "clayey" deposit in which the Galley Hill remains had been found 7 years previously. Mr. I. W. Cornwall kindly examined this sample for us in the Geochronology Laboratory, at the Institute of Archaeology, University of London. Briefly, he reports that it has a pH of 6.8 (confirming our impression of complete decalcification), with the following composition: sand 19%, silt 66%, clay 15%. Thus, far from being "a clayey deposit," we are here dealing with a waterlaid coarse gritty silt of permeable texture, which Mr. Cornwall suggests may contain redeposited loessic material.

The presence of the skeleton in two distinct types of matrices is suggestive of an artificial burial.

published methods, will be described in a forthcoming number of the Bulletin of the British Museum [Natural History]).

The following results were obtained:

	FLUORINE %
9 samples of fossil animal bone from loams and gravels in 100-ft. terrace (Middle Pleistocene)	<div> <div>{</div> <div>2.0</div> <div>2.8</div> <div>2.1</div> <div>1.7</div> <div>1.7</div> <div>2.3</div> <div>2.0</div> <div>2.0</div> <div>1.7</div> </div>
Samples of Swanscombe skull	
Occipital bone	<i>c.</i> 1.9
Parietal bone	<i>c.</i> 2.0
6 samples of fossil animal bones from loams and gravels in 50-ft. terrace complex (Upper Pleistocene)	<div> <div>{</div> <div>1.0</div> <div>1.2</div> <div>1.4</div> <div>0.9</div> <div>1.1</div> <div>1.0</div> </div>
5 samples of recent bones from soil or subsoil (Holocene)	<div> <div>{</div> <div>0.1</div> <div>0.1</div> <div>0.2</div> <div>0.3</div> <div>0.05</div> </div>
5 samples of Galley Hill skeleton	<div> <div>{</div> <div>petrous bone</div> <div>mandible, cancellous</div> <div>right tibia</div> <div>unident. limb bone</div> <div>left femur</div> <div>{</div> <div>0.3</div> <div>0.4</div> <div>0.4</div> <div>0.4</div> <div>0.2</div> </div>

These figures give striking confirmation that the Galley Hill skeleton, far from being Middle Pleistocene, is a comparatively recent burial. It is possible that if a longer series of determinations were made the Upper Pleistocene range might be extended to include the average value obtained for the F-content of the Galley Hill bones, but the balance of the available evidence indicates that this skeleton was probably buried in early post-glacial times.

## THE SKELETON

The following remains have been preserved and were studied (By M.F.A.M.):

*The skull*

The greater part of the calvarium, together with the lateral and inferior portions of the brain-box of the right side. Maximum breadth 111.5 mm. Actual maximum length 202.0 mm.<sup>2</sup>

Three small fragments of occipital bone, one showing part of the posterior margin of the foramen magnum.

The *right* half of mandible with chin and the two premolars and three molars in situ.

*Trunk*

Right clavicle with acromial and sternal portions missing. Three small portions of ribs.

About half of right acetabulum with small portions of ischium and ilium attached.

About half of left acetabulum with portion of ischium.

About a 4th of acetabulum with portion of ischium. Side unidentified.

*Upper extremity*

Portion of shaft of right humerus measuring 84.5 mm in length.

Portion of shaft of left humerus measuring 235.0 mm in length.

*Lower extremity*

Right femur complete except for missing greater and lesser trochanteric region. Maximum length 418.0 mm. Vertical diameter of head 33.0 mm.

Left femur in same state of preservation.

Right tibia with distal part as well as portion of superior articular surface wanting. Length 244.0 mm.

Newton (1895, p. 505) mentions only one humerus. "The shaft of the humerus" is what he wrote in his enumeration.

<sup>2</sup> All measurements represent the mean of three readings taken by M.F.A.M.

Actually the shafts of two humeri were recovered and preserved. From this list of remains it is legitimate to infer that a complete skeleton was actually present at Galley Hill, but that owing to their extreme softness, and the rather haphazard method of excavation, the other parts of the bones were lost. As a fair number of students of the Galley Hill problem have pointed out since Sir John Evans originally made the remark in connection with these remains, the occurrence of a nearly perfect skeleton is suggestive of an interment.<sup>3</sup> Keith ('29, p. 258), at one time the strongest proponent of the antiquity of Galley Hill Man, admitted that the weight of the evidence suggested a burial. Further evidence in support of this suggestion is to be found in the character of the breakage of the bones of the skull, and in the kind of warping which is so often encountered in skulls recovered from known burials.

Considerably more of the right side of the skull, including the mandible, is present than of the left side. Furthermore, the warping or torsion of the frontal bones is markedly to the right. These facts strongly suggest that the body lay on its right side and that the weight of the superimposed earth produced the distortion to the right, as well as the greater fragmentation of the bones of the left side. Duckworth ('13)

<sup>3</sup> In the discussion following the presentation of Newton's report on the Galley Hill skeleton before the Geological Society of London, May 22, 1895, Sir John Evans said, "The fact that the remains were found, not at the base of the gravels, like other bones from the same locality, but some few feet above the Chalk, was noteworthy; but what weighed most with him [Evans], and led him to doubt whether the bones were of the same age as the gravels, was the fact that nearly the whole skeleton, including the lower jaw and clavicle, had been preserved. Although occasionally in brickearth the bones of a limb might have been found together, it might be regarded as almost if not quite universally the case that in the gravels isolated bones only were found. The occurrence of a nearly perfect skeleton was suggestive of an interment; and the accumulation of surface-soil above the gravel might give the grave in which the body was deposited an appearance of having been of greater depth than it actually was. On the whole he [Evans] ventured to maintain an attitude of doubt, and would await further evidence before absolutely accepting these human remains, however ancient, as being of necessity contemporaneous with the beds in which they were found." Professor Boyd Dawkins, who also participated in the discussion, wholly agreed with Evans.



had already made out a strong case for the Galley Hill skeleton being a burial largely on the evidence of the distortion. In the light of the present investigation there can be little doubt that it is; moreover, evidence of antiquity is lacking.

Sir Arthur Keith ('31, p. 30, '48, p. 265) has recently abandoned his faith in the antiquity of Galley Hill Man on the ground that he finds it impossible to believe "that a race or type of mankind could continue for 100,000 years without undergoing evolutionary change." In earlier years in commenting on the characters of the skeleton Keith ('29) wrote, "The reader will have a difficulty in believing that human remains, to which so great an antiquity is assigned, do not show in their structure, as well as in their degree of fossilization, some evidence of their ancient origin. They do. In the first place, the condition of preservation is peculiar — quite unlike any bones of Neolithic or Paleolithic data I have ever seen. Mr. E. T. Newton is perfectly familiar with the degree of fossilization seen in bones from the 100-foot terrace. He and other authorities regard their condition as evidence of their high antiquity. Besides, there are in the Galley Hill skeleton some minor structural parts which indicate a primitive form of man. The skull is thick, the vault varying from 10 to 12 mm — altogether an exceptional measurement. The eyebrow ridges, although of modern, bipartite form, are yet exceptionally pronounced. The middle or supraciliary parts are continuous with the lateral or malar parts, as in the most civilized of modern races. In the lower jaw itself, some primitive features are present," (pp. 262-63).

So far as any evidences of fossilization are concerned these are completely wanting, as is sometimes the case with bones from this region of known Pleistocene age. The Galley Hill skull (together with the other bones) had been treated with "gelatine" shortly after it had hardened, and subsequently Elliott "dipped them in a solution to preserve them" (Newton, 1895, p. 519). These treatments have given the superficial surfaces of the bones an almost purplish hue. This color, at first glance, gives the appearance of considerable antiquity. Upon

close examination, however, it is found that the color is due to the artificial treatment which the bones received. Where the bone has been broken after it had been "dipped," the color is the same characteristic light beige as in bones of known post-glacial age. The bones are light in weight, unmineralized, and scarcely different in character from those of comparatively recent domestic animals the bones of which one may pick up from the surface in the vicinity of Galley Hill.

As a rule the bones of Paleolithic man are heavily mineralized, dense and thick. This is true of the human skulls found not more than 500 yards away at Baker's Hole and Swanscombe. The Galley Hill bones show none of these characteristics.

Newton (1895, p. 506) stated "The walls of the cranium are in most parts very thick, the middle of each frontal measuring as much as 12 millim." Following him Sir Arthur Keith has stated, in the passage already quoted, "The skull is thick, the vault varying from 10 to 12 mm — altogether an exceptional measurement." On the contrary the skull bones, far from varying from 10 to 12 mm, in fact vary from 3.9 to 10.0 mm. The following list presents the measurements taken of the thickness of the skull bones at definite anthropometric landmarks. The measurements were made with Ashley Montagu's sliding calipers ('37). The calipers (cranio-cephalometer) were checked for accuracy. For comparison with these measurements, similar measurements were made on 5 American White skulls taken at random from a dissecting-room population. These measurements are shown opposite those for Galley Hill. All measurements are in millimeters.

LANDMARK OR REGION	GALLEY HILL		AMERICAN WHITE SKULLS			
At pterion (right side)	3.9	3.0	4.0	3.7	4.0	4.5
10 mm above opisthoecranion	4.0	7.6	9.5	10.0	6.5	9.3
At lambda	7.1	9.4	8.0	7.9	10.0	7.6
At euryon (right side)	8.0	5.2	5.5	4.6	5.0	7.3
At bregma	8.0	7.3	6.0	5.2	6.1	7.6
At stephanion (right side)	10.0	7.4	5.0	4.9	6.7	8.0
"Middle of frontal" (Newton's measurement)	"10.0"	6.0	9.4	5.8	7.4	9.0

If we take the measurements of the Galley Hill skull and compare them with the measurements of the American White skull in the final column, it will be seen that at the pterion, above the opisthocranion, and at lamda, Galley Hill has thinner bones at these regions than this particular American White skull. At the 4 other regions Galley Hill has thicker bones, the advantage being 0.7 mm at euryon, 0.4 mm at bregma, 2.0 mm at stephanion, and 1.0 mm at "middle of frontal." With the possible exception of the 2.0 mm difference at stephanion, it will be generally agreed that these are hardly significant enough differences to justify the claims which have been made for the exceptional thickness of the Galley Hill skull bones. In brief, it is evident that the thickness of the Galley Hill skull bones falls well within the range of variation of the thickness of the skull bones of the modern White male.

The only remarkable feature of the Galley Hill skull is the rather extensive superior temporal line, but even this is well within the range of variation of modern European crania. The "eyebrow" ridges are of the modern bipartite form, and are not more pronounced than in numerous Englishmen of the present day.

Keith writes, "Fortunately, the greater part of the left half of the jaw was recovered" ('29, p. 261), and in his book he figures ('29, fig. 91, p. 261) the left half of the jaw. But in point of fact it was the *right* half which was recovered — the left half does not exist. Keith goes on to say, "In the Galley Hill ascending ramus a notch is almost absent." This is scarcely accurate. A notch is certainly present, but this appears to be more shallow than it originally was owing to the absence of the coronoid process and the loss of about half of the ascending portion of the ramus and its condyle. Newton's dotted-line reconstruction of these parts is inaccurate. The base of the notch is actually present in the Galley Hill mandible.

The following are some measurements of the mandible:

From base to anterior alveolar margin at PM <sub>1</sub>	32.8 mm
From base to anterior alveolar margin at M <sub>3</sub>	29.7 mm
From base to anterior alveolar margin at I <sub>1</sub>	21.4 mm
Genio-mental thickness	24.0 mm

A single pair of fused genial tubercles are present. The mental foramen opens laterally beneath the root of PM<sub>2</sub>. The appearance of the incisivo-mental region suggests the effects of an inflammatory condition, with some loss of bone at the chin.

According to Keith the size and shape of the mandibular fossa, the large external auditory meatus, the small mastoid process, and the extensive area for the attachment of the temporal muscle, are "characters seen on the skull of primitive races of modern type" or are otherwise peculiar.

The size and shape of the mandibular fossa are in no way remarkable. Absence of the tympanic plate and external auditory meatus may possibly tend to falsify the impression of size and shape, but close inspection will reveal that the fossa is perfectly modern in form.

I have already pointed out that the interpretation given to the form of the mandibular notch is rather more than open to question. That notch was almost certainly as deep as it is in contemporary man. With respect to Keith's statement that "The ear-hole is remarkably large" ('29, p. 263), it is only possible to say that when the skull was examined in the summer of 1948 the external auditory meatus was completely wanting on both sides of the skull, and this is the case in all the casts which have been examined. On the right side at least half of the petrous bone is missing, and it is wholly missing on the left side. There remains not the least trace of the "ear-hole." The indications are that the external auditory meati and tympanic plates were in a weakened state, and it is quite possible, indeed probable, when Newton's figure of the lateral aspect of the skull is examined (fig. 6), that the remaining meatus on the right side was lost some time after Keith had examined it. From Newton's figure it will be seen



that the external auditory meatus appears in no way remarkable. From that figure it will also be noted that the only remaining mastoid process, the right, is not unusually small.

Keith states, "The teeth themselves are not large, the total length of the crowns of the three molar teeth being 34.5 mm. The last molar is slightly longer than the second." Measurements recently taken of the length of the individual molars add up to a total length of the three crowns amounting to 33.3 mm. As will be seen from the following figures the second molar measured 11.4 mm, while the third molar measured 10.5 mm, the second therefore being longer than the third. The breadth of the third molar was also found to exceed its length.

*Measurements of the right mandibular molars of the Galley Hill Skull*

	LENGTH	BREADTH
M <sub>1</sub>	11.4 mm	10.5 mm
M <sub>2</sub>	11.4 mm	10.5 mm
M <sub>3</sub>	10.5 mm	10.9 mm

In any event, with respect to the lengths of M<sub>2</sub> and M<sub>3</sub>, consultation of table 2 in Gregory and Hellman ('26) will show that even in contemporary whites M<sub>3</sub> is frequently larger, antero-posteriorly, than M<sub>2</sub>.

The first and second molars present evidence, though this would be debatable, of what may have been caries. The first molar presents such evidence on the antero- and postero-lingual cusps down to the root distally, while the second molar shows evidence of possible caries in the lingual wall and occlusal surface of the crown. The canine tooth was lost post mortem. The appearance of the incisor sockets suggests that the incisors may have been lost ante mortem. There is evidence suggesting the presence of some inflammatory condition all the way down to the mentale, with some loss of bony tissue at the chin.

It should be evident that none of the features existing in the Galley Hill remains, alone or in combination, would be difficult to duplicate in contemporary human skeletons. There



are several features which are rather unusual, but these were almost certainly peculiar to this individual. For example, the right clavicle is very remarkably flattened antero-posteriorly, so that the body presents an almost quadrilateral form in cross-section. This type of flattening appears to have affected several of the long bones, the dorsal surfaces of both humeri, and the shafts of both tibiae. The femora are not markedly affected.

On morphological grounds, then, there exists no reason to believe that the Galley Hill skeleton presents any primitive features whatever. So far as fossilization is concerned the evidence is largely negative. The bones might be of any Quaternary age, but their morphological appearance and condition are post-Paleolithic rather than Paleolithic.

#### SUMMARY

It has been claimed that the human skeleton found in the Middle Pleistocene gravels at Galley Hill, Swanscombe, was an indigenous fossil and therefore of Early Paleolithic (Acheulian) age. The skull has been described as showing primitive features conformable with great antiquity.

From the statements of some authors it might appear that the skull is exceptionally thick, but remeasurement has shown that the bones are well within the range of variation found in modern Whites. The eyebrow ridges are not more pronounced than in many Englishmen of the present day. It has been stated that the mandible is of primitive type, and that the sigmoid notch is shallow. Re-examination has revealed no primitive features, the shallow appearance of the notch being due to the loss of the tip of the coronoid process and of half the ascending ramus.

Even the most fragmentary skeletal remains of Paleolithic man are excessively rare in fluvial deposits. With the exception of deliberate burials (and the earliest of these are Upper Pleistocene) the association of the articulated skull and limb bones of a single individual has not hitherto been recorded in undoubted river gravels anywhere in the world.

The published claims that this skeleton was indigenous rest on negative evidence. The collector declared that the overlying beds showed no signs of having been disturbed; but by the time he examined the section evidence of burial would have been largely—perhaps entirely—removed by the workman digging the gravel. Some accounts of the discovery give the impression that the bones were contained by a definite horizontal seam of loam within the gravels, but the indications are that their actual matrix was of a mixed character.

Wherever the Swanscombe gravels have been protected from intensive decalcification, as in the neighboring Barnfield pit, they have yielded numerous fragmentary animal remains. However, in the Galley Hill pit the gravels and intercalated loams have been almost completely decalcified, and so far as is known have never yielded any fossil animal bones or shells. The preservation of the human skeleton (which, it is important to note, was in a permeable matrix) is only accountable as an interment subsequent to the decalcification of the deposits.

The fluorine content of bones increases with geological age. Comparison of the F-content of the Galley Hill skeleton with that of 22 bones of known relative ages from various deposits in the same district confirms the conclusions that it was not indigenous to the Middle Pleistocene gravels in which it lay, but a burial of later date—prehistoric, but probably post-Pleistocene.

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before that, Deputy Manager of Swanscombe Cement Works). Their sympathetic interest and practical assistance made our field studies much lighter and more pleasant than they could otherwise have been.

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$a$  = chalk.  $b$  = gravel.  $c$  = wall, behind which is the high road.  
The figure on the right is represented as standing on the spot where the human remains were found.

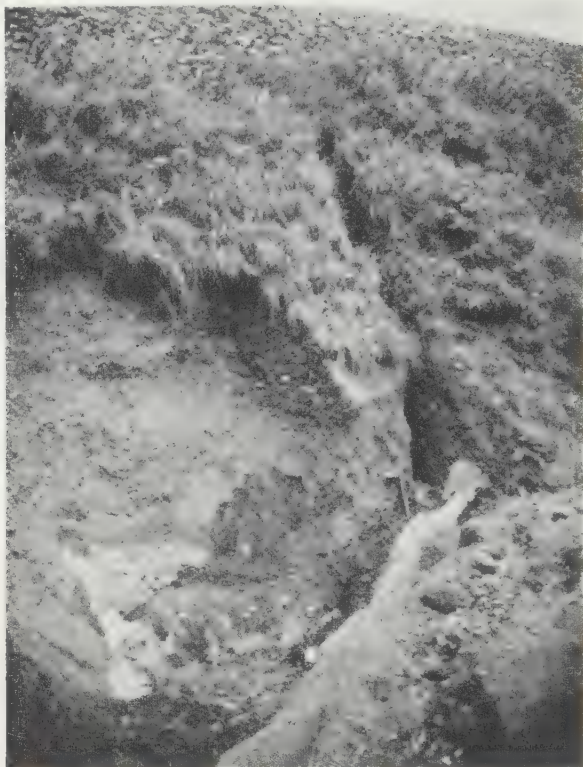
(From photographs by Mr. Clement Reid and Mr. J. W. Reed.)



Fig. 1 Newton's original figure of the Galley Hill site, 1895, (Courtesy of The Geological Society of London). Compare this with figure 2.

Fig. 2 Trench exposing stratified gravels, near site of skeleton. November 1948.





3



Fig. 3 Showing the stratified gravel above the Chalk. November 1948.  
Fig. 4 View from north side, looking south, showing site of skeleton.

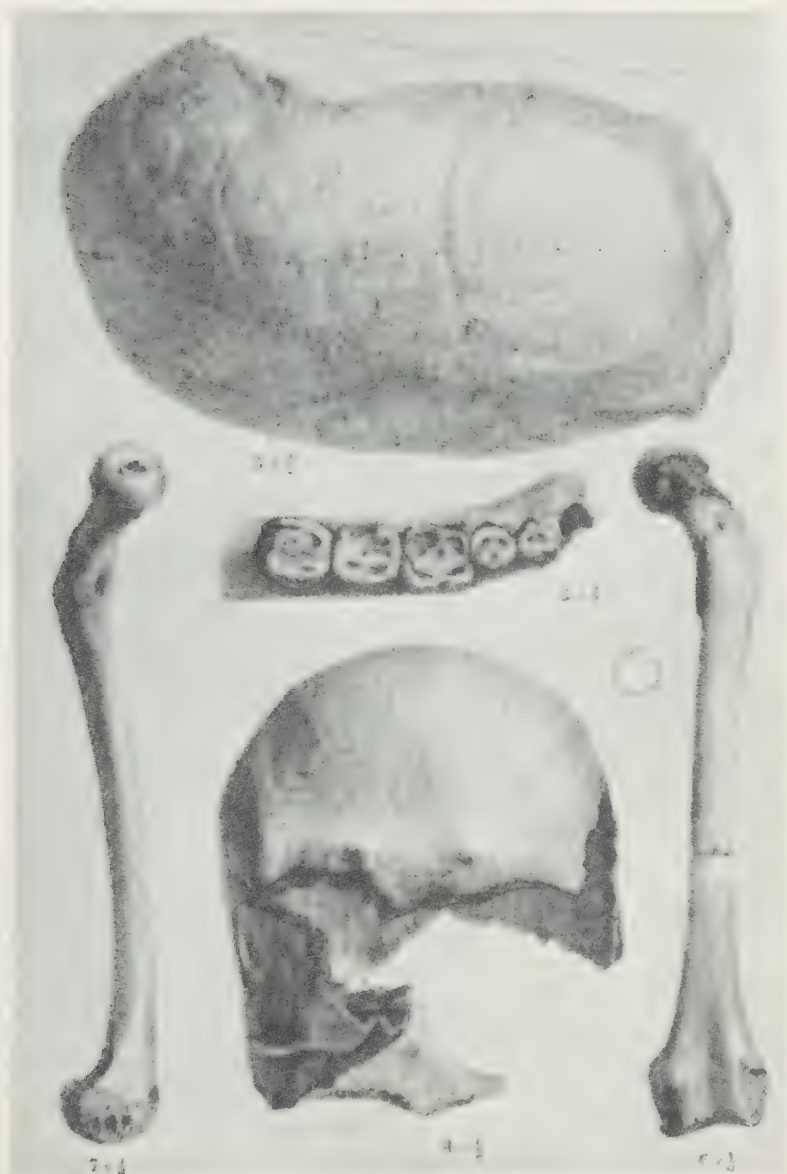


Fig. 5 Galley Hill skeleton. (From Newton, 1895, courtesy of the Geological Society of London.)

2. Occlusal view of teeth.
3. Vertical view of skull.
4. Frontal view of skull.
6. Right femur.
7. Left femur.



Fig. 6 Galley Hill skeleton. (From Newton, 1895, courtesy of the Geological Society of London.)

1. Skull and mandible. Right lateral view.
2. Occipital view of skull.
3. Right tibia.

# DIRECTION AND TYPE OF THE TRANSVERSE PALATINE SUTURE AND ITS RELATION TO THE FORM OF THE HARD PALATE

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EIGHT FIGURES

The hard palate is composed of the palatine processes of the maxillae and the horizontal parts of the palate bones. The former articulate posteriorly with the latter at the transverse palatine sutures. These sutures show a number of variations in their course. Sutures which curve backward were first noted by Meckel (1815). Topinard (1885) first described the form which curves forward and Gegenbaur (1898) reported the straight course of the sutures. Extreme cases of sutures that curve backward as far as the posterior margin of the hard palate, so that the palatine processes of the maxillae constitute the posterior nasal spine, were described by Henle (1871), Hyrtl (1884) and Waldeyer (1892). It was Stieda (1894) who first classified the different directions of the suture into three forms as transverse, forward and backward, and gave statistical data for each kind. He named the combination of any two of the three forms the "irregular" form. Matiegka ('00) further divided the irregular form into three kinds and Le Double ('06) made more minute divisions of the suture into 7 varieties.

Racial differences in the direction of the suture have been searched for by Stieda (1894) and Killerman (1894). However, owing to the small number of specimens examined no definite conclusion was reached by either author.



Various suggestions have been made to explain the different directions of the transverse palatine sutures. Stieda (1894) offered the explanation that the direction of the sutures was determined by two ossification centers appearing between the posterior border of the palatine processes of the maxillae and the anterior border of the horizontal parts of the palate bones and fusing either with the former or the latter. This idea may be attributed to Calori's finding of the medio-palatine bones (1868), which are a pair of small bones found in rare cases between the palatine processes of the maxillae and the horizontal parts of the palate bones (Woo, '48a). Killerman (1894) believed that the transverse and posterior directions are related to the brachystaphyline and the anterior direction to the leptostaphyline. In discussing the explanation of Stieda, Augier ('31) stated that the direction of the sutures is determined mainly by the horizontal parts of the palate bones. He holds that the anterior direction of the suture always indicates a hyperdevelopment of the horizontal parts of the palate bones at the cost of the palatine processes of the maxillae; that the transverse direction indicates more often a hypodevelopment but sometimes a hyperdevelopment of the horizontal parts of the palate bones; and that the posterior direction of the suture always indicates a hypodevelopment of the same parts of these bones.

It is generally considered that the transverse palatine suture belongs to the type of *serrate suture*. In textbooks of gross anatomy (Cunningham, '43; Gray, '48; Morris, '46 and Piersol, '36) the relation of the two parts forming the suture is described as serrately articulated, i.e., the two parts have saw-toothed interlocking processes. However, Woo ('48b) has shown recently that it is a type of *squamous suture*.

The present paper will provide data for comparisons of the different directions of the transverse palatine sutures in 5 different racial groups and an explanation of the different directions will be given in terms of the type of the suture and the size of the hard palate.



## MATERIAL AND METHOD

The hard palates of 1,531 adult skulls of American Whites and Negroes in the Terry Anatomical Collection of Washington University were studied. Three other series (Eskimo, 189 males and 164 females; American Indian, 94 males and 77 females; and Mongolian, 91 males and 67 females) were observed in the U. S. National Museum during the summer of 1948. The direction of the suture is classified according to its course on the oral or inferior surface under 4 categories: anterior (fig. 2); posterior (fig. 3); transverse (fig. 4); and irregular (fig. 5). The anterior direction is that in which the sutures on both sides curve generally forward and the posterior one, generally backward. The transverse direction refers to sutures having their courses approximately at right angles to the median palatine suture. When the direction of the sutures on the two sides is different or the suture is irregular in itself, it falls into the irregular category.

The hard palates of 319 sagittally sectioned skulls among the American White and Negro series were studied to determine the type of the transverse palatine sutures. Of the 319 skulls, both the right and left halves were suitable for observation in 42 skulls. In the remaining 277 skulls, as they had been sectioned either a little to the right or left of the mid-line in order to preserve the nasal septum intact, one side only was observed. In addition, the hard palates of 64 embryos and fetuses ranging in age from 6 weeks to full term were examined. The fetal skulls had been cleared with KOH and stained with alizarin red.

The suture line on the oral or inferior surface of the hard palate can be seen on the nasal or superior surface by holding the half skull before a strong light and may be traced on the superior surface with the sharp point of a pencil. Thus, a line can be made on the superior surface of the hard palate corresponding to the position of the transverse palatine suture on the inferior surface. The extent of overlapping by the two bones was made possible for measurement with a sliding caliper and measurement of the greatest extent of

overlapping was taken in the 319 adult skulls. The development of overlapping in different gestation periods of embryos and fetuses from 6 weeks on to full term was noted.

The size of the hard palate was ascertained with a sliding caliper according to its length and breadth. The length was taken between the midpoint of a line tangent to the posterior alveolar border of the median incisors and the midpoint of a transverse line connecting the most anterior points of the notches in the posterior border of the palate. The breadth was taken between the internal alveolar borders at the second molar teeth.

## RESULTS AND DISCUSSION

### *Degree of overlapping*

From observation of the 319 adult skulls which had been sagittally sectioned, and on which the suture lines of both the oral and nasal surfaces were clearly seen, it appears that the palatine processes of the maxillae and the horizontal parts of the palate bones overlap instead of being serrately articulated. The palatine process of the maxilla and the horizontal part of the palate bone overlap in the extent of their bevelled edges with the maxillary portion in the inferior position.<sup>1</sup> Overlapping of the two bones forming the suture in adult skulls is shown in figure 7. The greatest extent of overlapping in each adult skull was measured and the results are summarized in table 1. The extent of overlapping is usually greatest in the lateral portion of the suture and was found to range from a slight degree to 8 mm. As is shown in table 1, the difference between the right and the left sides is slight. The females in both series have a slightly greater extent of overlapping than do the males, and the extent of overlapping in American Whites is slightly less than in American Ne-

<sup>1</sup> In 6 cases or 1.9% of the 319 skulls the lateral part of this portion of the palate bone was covered superiorly by a second layer from the vertical portion of the maxillary process so that a small portion of the palate bone is actually inserted into the double layer of maxilla.

groes. However, these differences are not statistically significant.

Of the 64 embryos and fetuses studied, 49 were of more than 10 weeks' gestation and all show the overlapping condition. It is in the 10th week (CR 45 mm) that the overlapped condition begins to appear (fig. 8).

The overlapped condition is also present in all of the 14 skulls of apes and monkeys and in the one dog skull examined.

Thus, the articulation of the transverse palatine suture belongs to the type of *squamous suture* instead of *serrate suture*, as is generally described. This seems to be true at least for primates and possibly for all mammals.

TABLE 1

*Extent of overlap of the bones forming the transverse palatine suture in American Whites and Negroes*

GROUP	SEX	MEAN GREATEST EXTENT OF OVERLAP (IN MM)			
		Right	(cases)	Left	(cases)
American	M	3.41	(74)	3.27	(61)
White	F	4.02	(14)	3.64	(14)
American	M	3.74	(88)	3.74	(50)
Negro	F	4.24	(28)	4.53	(24)

### *Direction of transverse suture*

Percentages of the different directions of the transverse palatine sutures are given in table 2, according to the racial groups examined and to sex. It is seen that the corresponding directions in the two sexes in all the 5 series studied are quite similar in percentages. However, percentages of the anterior direction of the suture in the male are higher than in the female in all the 5 groups though the differences are not statistically significant. There seems to be no true sexual difference in direction of the transverse palatine suture. Percentages of the directions of the transverse palatine sutures in different groups reported by Stieda (1894) are also given in table 2. (Only those series of Stieda with more than 100 cases are included.) In general, the anterior direction of the

transverse palatine sutures is most frequent, and the irregular form the least. The American Negro series has the highest percentage of anteriorly directed sutures and the lowest percentages of transversely and posteriorly directed sutures. The American White series of the present study shows a similar

TABLE 2

*Classification of the direction of the transverse palatine sutures  
(in per cent) according to racial group and sex*

GROUP	AUTHOR	SEX	CASES	ANTE- RIOR	TRANS- VERSE	POSTE- RIOR	IRREGU- LAR
American Negro	(present paper)	M	573	89.01	6.81	3.14	1.05
		F	299	85.62	8.03	4.01	2.34
American White	(present paper)	M	534	70.41	18.73	7.87	3.00
		F	126	69.05	18.25	8.73	3.97
Eskimo	(present paper)	M	193	57.51	30.05	9.33	3.11
		F	173	56.65	31.79	9.25	2.31
American Indian	(present paper)	M	95	56.12	34.69	5.10	4.08
		F	77	55.70	37.97	3.80	2.53
Mongolian	(present paper)	M	91	53.85	28.57	10.99	6.59
		F	67	53.73	31.34	10.45	4.48
East Prussian	Stieda (1894)	M & F	980	67.24	17.14	10.61	5.00
Melane- sian	Stieda (1894)	M & F	198	47.97	40.40	5.55	6.06

result to the East Prussian series of Stieda (1894). The percentage of the anteriorly directed sutures is smaller and percentages of the transversely and posteriorly directed ones are greater in the American Negro series than in the American White one. Mongolians, Eskimos and American Indians all have lower percentages of the anterior direction and higher percentages of the transverse and posterior directions than do the other groups. Melanesians have the lowest percentage of the anterior direction and the highest percentage of the transverse direction.

*Relation of palatal form to suture direction*

The palatal length, breadth and index in the different series are listed in table 3. It is seen that the males in all series have greater absolute size than do the females whereas the index of the palate of the males is smaller than that of the females, with the exception of the American Indian series in which the males have greater relative breadth of the palate, perhaps due to the small number of cases. The American

TABLE 3  
*Palatal length, breadth and index in different groups*

SERIES	SEX	CASES	LENGTH		BREADTH		INDEX	
			Range	Mean	Range	Mean	Range	Mean
American Negro	M	573	39.0-62.0	49.73	28.0-47.0	38.29	61.67-102.44	77.27
	F	299	39.0-55.5	47.43	30.0-47.0	37.17	60.00-101.22	78.67
American White	M	534	33.5-56.0	44.47	29.5-46.0	36.82	63.37-104.55	83.15
	F	126	34.0-55.5	42.81	29.0-43.0	36.53	61.26-103.75	85.54
Eskimo	M	189	40.5-57.0	48.36	33.0-49.5	41.10	66.36-102.17	85.22
	F	164	40.0-53.0	46.00	32.0-48.5	39.80	69.57-103.61	86.78
American Indian	M	94	41.0-54.0	47.89	36.0-51.0	41.83	74.00-100.00	87.55
	F	77	36.5-52.5	46.36	30.0-48.0	40.15	72.12-104.44	86.70
Mongolian	M	91	38.0-53.0	46.61	35.0-47.0	40.91	71.43-107.14	88.09
	F	67	37.0-53.0	43.31	34.0-44.4	39.40	78.30-105.13	91.31

Negroes have the greatest mean palatal length, and the American Indians the greatest mean palatal breadth. It is interesting to note that values of the mean palatal indices in the different series increase in the order that the percentages of the anterior directions of the different series decrease. Thus, the American Negro series has the smallest mean palatal index and the greatest percentage of the anteriorly directed transverse palatine sutures, whereas the Mongolian series has the greatest mean palatal index and the smallest percentage of the anteriorly directed sutures. It is also of interest to note that the females in all series have higher mean palatal indices than do the males excepting in the American Indians.



As mentioned above, the males in all the 5 series have higher percentages of the anteriorly directed transverse palatine sutures than do the females. This may be interpreted to indicate that the direction of the transverse palatine suture is related to the breadth of the hard palate. For further evidence, the percentages of directions of the transverse palatine sutures in different palatal index ranges in the two large series, viz., the American White and Negro, are listed in tables 4 and 5. It is clearly seen that in both series the anteriorly directed sutures decrease in percentage whereas the transversely and posteriorly directed sutures increase as the

TABLE 4

*Percentages of directions of the transverse palatine sutures in different palatal index ranges in American White series*

P. I. RANGE	CASES	ANTERIOR	TRANSVERSE	POSTERIOR	IRREGULAR
60-64.9	2	100.00	0	0	0
65-69.9	19	89.47	5.26	5.26	0
70-74.9	56	87.50	5.36	3.57	3.57
75-79.9	137	78.10	10.22	8.03	3.65
80-84.9	175	73.71	17.14	6.86	2.29
85-89.9	121	66.94	23.97	6.62	2.48
90-94.5	96	60.42	23.96	12.50	3.13
95-99.9	36	47.22	36.11	13.89	2.78
100-105	18	16.67	55.56	16.67	11.11

palatal indices increase. Figure 1 shows the trends in both series, as listed in tables 4 and 5 respectively, by graphs. It may be seen that the curves of the transversely and posteriorly directed sutures gradually rise as the palatal indices increase though the latter increases more slowly than the former. On the other hand, the curve of the anteriorly directed transverse palatine sutures drops as the palatal indices increase. Though the distributions of the percentages of the different directions of the suture differ somewhat in the American White and Negro series, they show the same trends as seen in figure 1. Thus, the directions of the transverse palatine sutures are related to the relative breadth of the hard

palate. The narrow palates have a higher percentage of the anteriorly directed sutures and lower percentages of the transversely and posteriorly directed ones.

In conclusion, as the palatine processes of the maxillae and the horizontal parts of the palate bones overlap in the extent of their bevelled edges with the maxillary portions in the inferior position, the directions of the transverse palatine sutures as seen on the oral or inferior surface of the hard palate are expressions of the extent of the palatine processes of the maxillae, instead of the palate bones as suggested by Augier ('31), and in turn they are related to the relative breadth of the hard palate.

TABLE 5

*Percentages of directions of the transverse palatine sutures in different palatal index ranges in American Negro series*

P. I. RANGE	CASES	ANTERIOR	TRANSVERSE	POSTERIOR	IRREGULAR
60-64.9	25	92.00	4.00	0	4.00
65-69.9	90	96.67	2.22	1.11	0
70-74.9	170	92.35	5.29	1.18	1.18
75-79.9	258	89.92	5.04	3.10	1.94
80-84.9	205	84.88	8.78	4.39	1.95
85-89.9	86	81.40	13.95	4.65	0
90-94.9	27	66.67	22.22	11.11	0
95-99.9	9	44.44	22.22	22.22	11.11
100-105	2	0	50.00	50.00	0

## SUMMARY

Hard palates of 2,214 skulls in 5 different racial groups and of 64 embryos and fetuses ranging in age from 6 weeks to full term were studied.

The palatine processes of the maxillae and the horizontal parts of the palate bones overlap in the extent of their bevelled edges with the maxillary portions in the inferior position. Thus, the articulation belongs to the type of *squamous suture* instead of *serrate suture*.

The parts of the two bones forming the suture begin to overlap at the age of 10 weeks in the embryo.

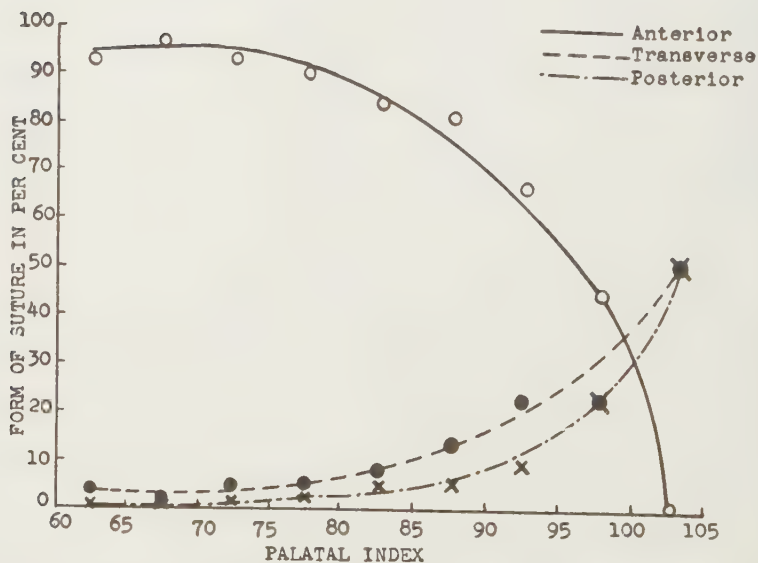
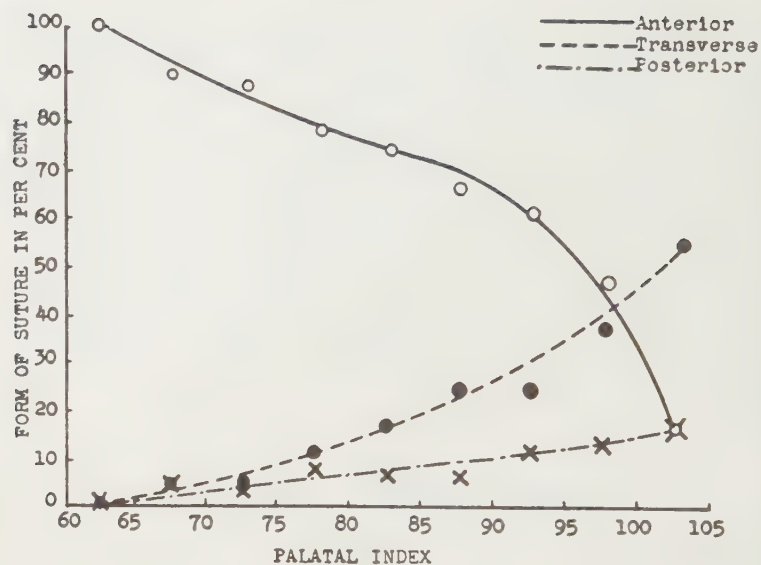


Fig. 1 Relation between the form of the transverse palatine suture and the index of the hard palate in American White (upper) and American Negro (lower) series.

The anteriorly directed transverse palatine suture is most frequent, the irregular form, the least.

The males in all series have higher percentages of the anteriorly directed sutures than do the females, though the differences are not statistically significant.

The American Negro series has the highest percentage of the anteriorly directed suture and the lowest percentages of the transversely and posteriorly directed ones. The American White series has a lower percentage of the anteriorly directed and higher percentages of the transversely and posteriorly directed sutures than do the American Negroes. Mongolians, Eskimos and American Indians all have lower percentages of the anteriorly directed and higher percentages of the transversely and posteriorly directed sutures than do the other two series.

The males in all series have a greater absolute size of the hard palate than do the females, whereas the index of the palate of the males is smaller than that of the females.

American Negroes have the greatest mean palatal length, and American Indians the greatest mean palatal breadth.

The direction of the transverse palatine suture as seen on the oral surface of the hard palate is an expression of the extent of the palatine process of the maxilla and is related to the relative breadth of the hard palate. Narrow palates have a higher percentage of the anteriorly directed and lower percentages of the transversely and posteriorly directed transverse palatine sutures than do broader palates.

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The writer is grateful to Dr. T. D. Stewart for the permission to study the fine collections of the U. S. National Museum and to Dr. Mildred Trotter for suggestions and help.

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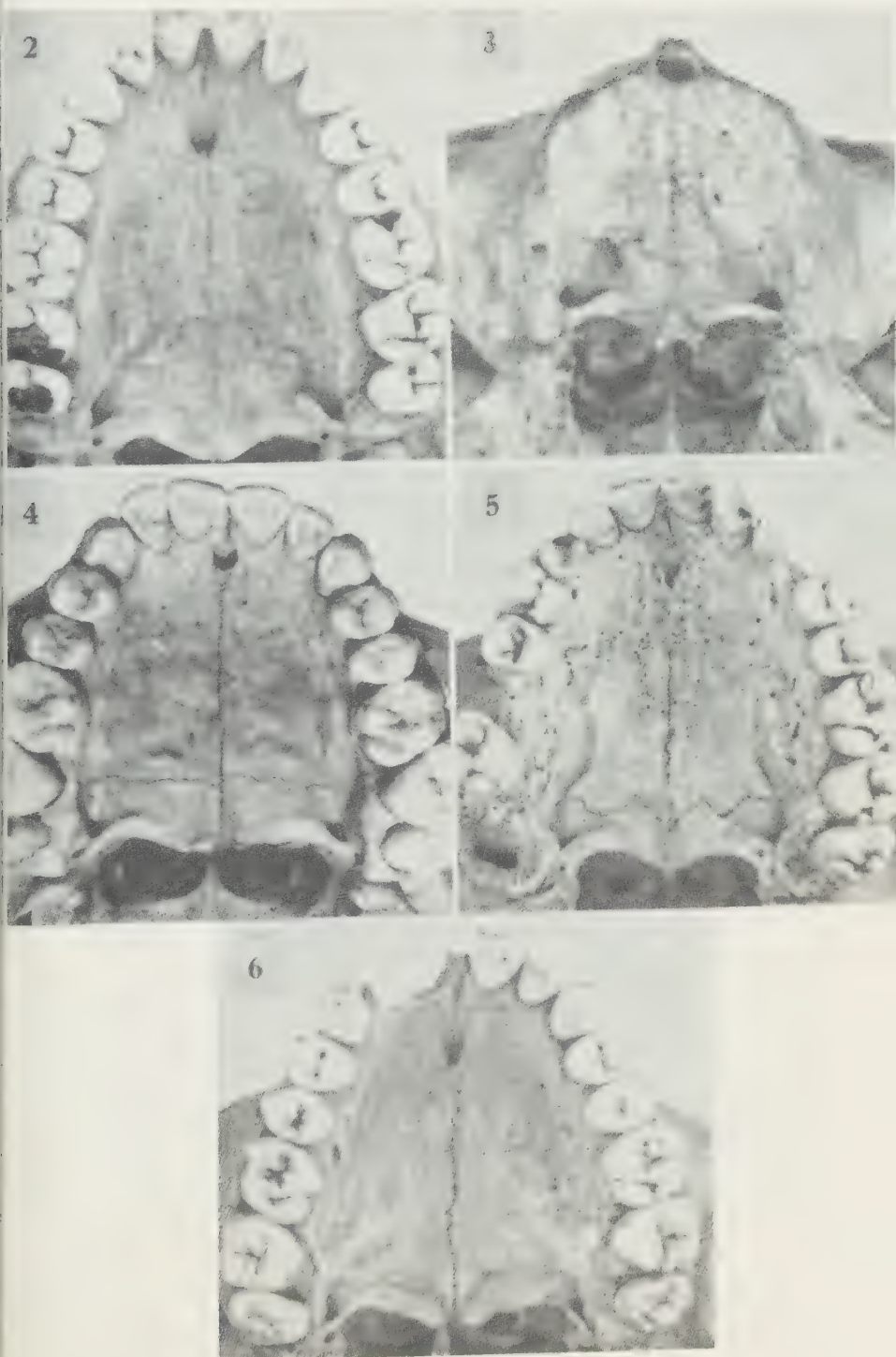
## PLATE 1

### EXPLANATION OF FIGURES

#### Directions of transverse palatine suture

- 2 Anterior
- 3 Posterior
- 4 Transverse
- 5 Irregular
- 6 Extreme case of the posterior direction in which the sutures curve backward as far as the posterior margin of the hard palate so that the palatine processes of the maxillae constitute the posterior nasal spine.





## PLATE 2

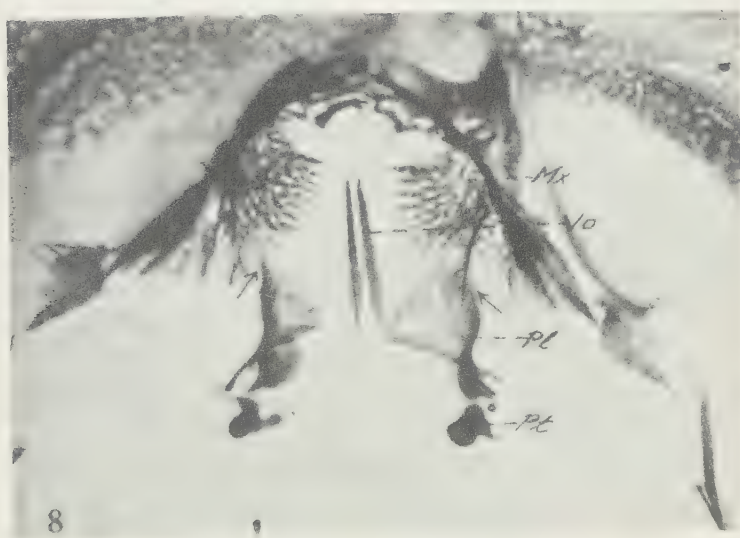
### EXPLANATION OF FIGURES

Overlapping of the two bones forming the transverse palatine suture

7 Inferior and superior surfaces of the right half of an adult skull showing the condition of overlapping. Note the difference in distance of the suture from the posterior border of the palate bone in the two surfaces.

8 Inferior surface of the hard palate of a fetal skull of 10 weeks showing the beginning of the overlapping condition (indicated by arrow-heads).  $\times 8$ .

Mx., maxilla; Vo., vomer; Pl., palate bone; Pt., pterygoid plate.





**STUDY ON PALATINE RIDGES.**—On the well founded assumption that 7 to 9 ridges on each side of the palate represents the primitive, undifferentiated condition, it may be concluded that tarsius, howler monkeys, and chimpanzees have shared the trend to increase the number of rugae, and that the Hapalidae, gorilla, and man have become specialized in the opposite direction by having reduced numbers of ridges. . . .

The present study supports the conclusion that the number, arrangement, and relative size of the palatine ridges remain unchanged throughout growth in man, just as in other primates. . . .

The palatine ridges of single ovum [human] twins show only a limited degree of resemblance, similarities being usually more marked in the anterior than in the posterior ridges. It can be tentatively stated that the details of the ridge patterns are not closely determined by heredity, but that the general degree of regularity or irregularity of ridge patterns and the tendency toward ramification or discontinuity of the ridges must have a genetic basis.—Adolph H. Schultz. The palatine ridges of primates. Carnegie Institution of Washington Publ. no. 583; Contributions to Embryology, vol. 33, no. 215, 1949, pp. 43–66 (with illustrations of 100 specimens).

**NEW ARGENTINE PERIODICAL.**—The Institute of Anthropology which was established in the Faculty of Philosophy and Letters (University of Buenos Aires) in 1947 is the source of a new publication dedicated to the “Sciences of Man.” Bearing the title RUNA: Archivo para las Ciencias del Hombre,” parts 1–2 of volume 1 (324 pp.) carry the date 1948. The word “Runa,” meaning man, comes from the language of ancient Peru. No editor is named, but José Imbelloni, director of the Institute and of the Ethnographic Museum, has written the foreword.

In this first issue the following articles are of special interest to physical anthropologists:

OSVALDO L. PAULOTTI. Los Toba; contribución a la somatología de los indígenas del Chaco.

J. IMBELLONI. De la estatura humana; su reivindicación como elemento morfológico y clasificatorio.

# SEX DIFFERENCES IN THE PELVES OF PRIMATES

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THREE FIGURES

## INTRODUCTION

Secondary sex differences are very pronounced in the pelvis of adult man, as has been amply demonstrated. Do these differences represent a human peculiarity, or are they comparable in character and degree to sex differences in the pelves of non-human primates? This study is an attempt to answer these questions by briefly reviewing the scanty literature on the subject and by contributing some new pertinent data to permit a preliminary survey of pelvic sex differentiation among primates.

In a special publication on sex differences in pelves of monkeys and apes, van den Broek ('11) had concluded that practically all the pelvic characters which tend to separate the sexes in man show also more or less marked sex differentiation in the non-human primates. From a later and much more detailed paper on the primate pelvis by the same author ('14) it is apparent that the above sweeping claim was very inadequately supported. Analysis of van den Broek's recorded data reveals that he had available only a few specimens of known sex for species with both sexes represented,<sup>1</sup> and

<sup>1</sup>The actual numbers of specimens are as follows, including some certainly immature great apes: "*Oedipomidas oedipus*" 1 ♀ 1 ♂, "*Cebus speciosus*" 1 ♀ 1 ♂, "*Macacus cynomolgus*" 1 ♀ 4 ♂, "*Macacus rhesus*" 2 ♀ 2 ♂, "*Symphalangus syndactylus*" 5 ♀ 3 ♂, "*Simia satyrus*" 7 ♀ 4 ♂, chimpanzee 10 ♀ 9 ♂, gorilla 7 ♀ 8 ♂.



that this scanty material includes not only adults, but also juveniles. To anyone today, familiar with the great variability of the metric characters of the pelvis and their close dependence upon age, it is evident that van den Broek could not have proved his broad conclusions with his extremely limited material. At one place he ventured the generalization that sex differentiation of the pelvis is less developed in the anthropoid apes than in the monkeys, i.e., he found the clearest sex differences in the species most poorly represented among his material!

In a study on the ilium of primates Straus ('29) obtained consistent average sex differences in the percentage relation between the upper and the lower iliac heights in large series of human pelves and in small series of pelves of anthropoid apes and macaques. According to this index, that part of the ilium forming and lying above the sacro-iliac joint is on an average proportionately larger in males than in females, not only in man but also in the apes and in macaques. The enormous ranges of individual variation, however, overlap in the two sexes very extensively in all the series studied, except in the small series of gorillas (3 ♀, 6 ♂).

In a number of former papers the writer ('40, '41, '42, and '44) has recorded sex differences in the breadth of the pelvic inlet in relation to the trunk height and, particularly, the maximum pelvic breadth, and was able to show on the basis of very considerable material that, on an average, the pelvic inlet is proportionately wider in females than in males of proboscis monkeys, gibbons, orang-utans, and chimpanzees. A corresponding sex difference has been found in many groups of man (e.g., Martin, '28, p. 1126, data for measurements 2 and 24).

In one species of macaques and in two species of langurs Washburn ('42) discovered a very striking sex difference in the length of the pubic bone relative to the length of the ischial bone. The ranges of variation for this proportion did not overlap in the extensive series of females and of males. In a recent study Washburn ('48) found that this same pelvic

index is also quite distinct in females and males of whites and negroes, though in these large series the ranges of variation for the two sexes overlap slightly.

In view of the fact that, in studying pelvic sex differences among primates, Washburn obtained more definite results with the ischium-pubis index in some monkeys and in man than the author had found with the relative pelvic inlet breadth in other primates, it is of special interest to gain more information on the ischium-pubis index in a larger variety of primate species and to compare both these pelvic indices in the same series of specimens whenever possible. For this undertaking the writer had already available a large amount of data of all 4 pelvic measurements needed for the two indices. These measurements are part of the routine, detailed records on primate skeletons which the author has collected for many years.

The findings from a statistical analysis of the writer's data, together with a consideration of Washburn's published results, have led to questions regarding the possible causes of sex differences in the pelves of primates. The second part of this paper represents an initial attempt to answer these questions, as far as morphology alone can do so, by pointing out certain conditions which are at least correlated, if not directly connected, with pelvic sex differences.

It is a pleasure to mention here that this study was facilitated in various ways by a recent grant from the Viking Fund which has already been of great aid in the preparation and utilization of the writer's material and records.

#### MATERIAL AND TECHNIQUE

All of the material used for this study had been measured by the author during past years while collecting systematic records on primate skeletons. Two hundred and five of the specimens are in the collections of the writer's laboratory, and the others belong to many different institutions, most of which have already been fully referred to in previous

publications by the author. Some skeletons of adult African great apes have been received on loan during the last year through the kindness of Dr. N. L. Hoerr and Dr. C. E. Snow. The numbers of specimens, available for this study, are listed according to species and sex in table 1. The ischium-pubis index could be calculated for a total of 479 specimens and the relative pelvic inlet breadth for a total of 485 specimens.<sup>2</sup> This material consists of fully adult primates, with the exception of the separate series of 17 sub-adult gibbons and 9 sub-adult chimpanzees, used exclusively for determining the stage of development at which pelvic sex differences appear. In all adult specimens the permanent dentition is complete and in the sub-adult specimens some or all of the third molars and at times some of the canines are incompletely erupted, but all other teeth are fully out. All the rhesus monkeys and some of the chimpanzees are captive specimens, but these do not include any pelvises suspected of having been affected by any pathological process. The other series of non-human primates contain only wild-shot specimens. There can be no doubt regarding the sex of all of these pelvises since sex could be recorded from the cadaver before preparation of the skeleton in all cases, except some of the adult great apes. The sex of the latter could be determined with certainty from the skull and dentition.

The ischium-pubis index, introduced by the author ('30) in a former study on primate skeletons, expresses the pubis length in percentage of the ischium length. The technique employed in taking these measurements has already been described in detail in this earlier paper. The relative pelvic inlet breadth is the percentage relation between the greatest

<sup>2</sup> As shown by table 1, the series used for the two pelvic indices differ slightly in a few instances. In some specimens the pelvis was broken or incomplete so that the pelvic inlet breadth and maximum pelvic breadth could not be measured reliably. The ischium-pubis index was not calculated for the author's small series of Negroes since data for this index in a much larger series had already been contributed by Washburn. The author's earliest records on gorilla skeletons from other collections do not include the pelvic inlet breadth, so that, unfortunately, the relative inlet breadth could be figured for only a small series of gorillas.

breadth of the pelvic inlet (= maximum transverse distance between *lineae arcuatae*) and the greatest pelvic breadth (wherever found between iliac crests or anterior iliac spines). The last two measurements are taken on articulated pelves, as ligamentous preparations or held together by means of very thin layers of wax or cement.

SEX DIFFERENCES IN ABSOLUTE SIZE OF  
PELVIC MEASUREMENTS

The first column of figures (*A*) in table 1 gives the average body weight of adult females in percentage of the average body weight of adult males for each of the species used in

TABLE 1

*Means of pubis length, ischium length and pelvic inlet breadth in series of female and male primates measured by the author. All specimens are fully adult, except the supplementary series of sub-adult gibbons and chimpanzees. The data in column A show the average body weight of adult females in percentage of the average body weight of adult males of the same species. The data for Negroes marked with asterisks are according to Washburn ('48)*

SPECIES	A	SEX	SPECI- MENS	PUBIS LENGTH	ISCHIUM LENGTH	SPECI- MENS	PELVIC INLET BREADTH
Ateles geoffroyi	109	♀	7	44.9	44.4	7	54.4
		♂	5	41.0	45.6	5	50.4
Macaca mulatta	68	♀	41	42.4	44.3	41	50.9
		♂	28	41.0	49.4	28	50.4
Nasalis larvatus	49	♀	15	43.5	44.9	15	51.8
		♂	10	48.8	56.5	10	58.8
Hylobates lar	93	♀	87	38.8	38.2	87	55.9
		♂	100	36.3	39.2	96	51.4
Sub-adult		♀	7	29.6	33.0	7	39.7
Hylobates lar		♂	10	31.2	35.3	10	42.5
Hylobates moloch	97	♀	7	41.0	38.0	7	54.1
		♂	11	36.9	38.9	10	49.5
Orang-utan	49	♀	26	79.7	74.5	26	102.5
		♂	24	85.1	86.9	24	98.5
Chimpanzee	88	♀	30	74.8	85.9	29	98.0
		♂	21	74.8	90.7	21	91.2
Sub-adult		♀	5	62.8	82.4	5	82.4
Chimpanzee		♂	4	60.0	77.3	4	76.5
Gorilla	49	♀	15	101.2	103.0	10	122.6
		♂	26	123.3	131.7	13	132.9
Negro	84	♀	50*	73.5*	77.5*	10	121.6
		♂	50*	69.2*	86.6*	20	112.4



this study, according to some data from the literature and, chiefly, those of the author.<sup>3</sup> These figures represent merely approximations, being based mostly on small series only, but they suffice to indicate here that general body size can be very different for the two sexes in some species, whereas nearly alike in males and females in other species. This fact, naturally, has to be taken into consideration when comparing absolute measurements of skeletal parts.

The ischium length is on an average larger in males than in females in all the species examined, except in the very limited series of sub-adult chimpanzees which happens to include one unusually small male. The pubis length, however, averages more in adult females than in adult males in those species in which the body weight of the former amounts to more than half that of the latter. The only exception is found in the chimpanzee, in which there is no sex difference in average pubis length. The averages of the pelvic inlet breadth are larger in adult females than in adult males in all the species, except in the proboscis monkey and the gorilla, which have extremely large sex differences in general body size. From these data in table 1 it can be concluded that the adult female primates, used here, tend to surpass the corresponding adult males in the length of the pubic bone and in the width of the pelvic inlet, if body size is duly considered. This anticipates the general results obtained from a study of the two indices, to be discussed below.

#### SEX DIFFERENCES IN THE ISCHIUM-PUBIS INDEX AND THE RELATIVE PELVIC INLET BREADTH

The averages and ranges of variation of the two pelvic indices, selected for this paper, are listed in table 2. According to these data the adult females surpass the corresponding adult males regarding averages as well as minimum and maximum variations of both indices in all the monkey, ape and human series for which information has become available.

<sup>3</sup> Most of these body weights have been published in more detail in former papers by the author ('40, '41, '42, '44, and '47).



In the sub-adult specimens, however, there exist at best only negligible sex differences in these indices. It appears, therefore, that growth in the length of the pubic bone and in the width of the pelvic inlet is more intense in females than in

TABLE 2

*Means and ranges of variation of the ischium-pubis index and the relative pelvic inlet breadth in the series measured by the author and those recorded by Washburn ('42 and '48). The latter are indicated by asterisks and the numbers of specimens are given in parentheses. The numbers of specimens in the author's series are the same as shown in table 1*

SPECIES	SEX	ISCHIUM-PUBIS INDEX		REL. PELVIC INLET BR.	
		Mean	Range	Mean	Range
Ateles geoffroyi	♀	100.8	95.0-106.7	51.8	50.5-53.3
	♂	89.9	84.1-95.6	48.3	45.7-50.0
Macaca mulatta	♀	95.7	84.4-107.3	59.3	53.4-67.5
	♂	82.9	72.0-90.7	52.8	46.0-56.8
Macaca irus (11 ♀ and 15 ♂)	♀	105*	97-116*		
	♂	84*	80-93*		
Trachypithecus pyrrhus (22 ♀ and 12 ♂)	♀	102*	91-109*		
	♂	80*	75-85*		
Presbytis rubicunda (17 ♀ and 19 ♂)	♀	91*	83-100*		
	♂	68*	62-74*		
Nasalis larvatus	♀	96.9	93.3-100.0	49.3	46.5-56.4
	♂	86.4	79.2-92.9	45.0	39.1-48.0
Hylobates lar	♀	101.6	90.5-115.8	57.5	52.1-68.7
	♂	92.7	82.9-100.0	54.0	45.6-63.1
Hylobates lar sub-adult	♀	89.6	87.1-93.7	53.2	50.7-56.1
	♂	88.3	82.3-94.7	52.7	49.4-55.3
Hylobates moloch	♀	108.1	95.0-118.9	52.0	48.1-58.1
	♂	95.0	85.4-102.6	49.6	42.7-56.8
Orang-utan	♀	107.0	96.2-118.1	42.9	39.2-46.1
	♂	97.8	84.6-108.4	36.0	30.9-39.4
Chimpanzee	♀	87.0	78.9-98.9	41.0	36.8-47.0
	♂	82.6	69.7-95.2	36.9	31.1-41.4
Chimpanzee sub-adult	♀	76.2	67.1-88.4	36.6	34.1-41.0
	♂	77.6	75.0-84.0	36.4	35.1-38.3
Gorilla	♀	98.3	85.4-113.7	37.5	34.8-41.6
	♂	93.6	82.3-108.3	33.0	29.6-34.6
Negro (50 ♀ and 50 ♂)	♀	95.0*	84-106*	49.5	47.2-52.2
	♂	79.9*	71-88*	44.1	40.6-48.4
White (100 ♀ and 100 ♂)	♀	99.5*	91-115*		
	♂	83.6*	73-94*		

males chiefly during that relatively short period represented by the terminal phase of dental eruption. This period probably begins with the full attainment of sexual maturity which usually antedates adulthood, as measured by the completion of the dentition. After adulthood has been reached these sex differences do not become more pronounced to any significant extent, at least according to the following observations. If the large series of adult female *Hylobates lar* is divided into a group (47 specimens) with no, or only moderate, attrition of the teeth, and a remaining group (40 specimens) with marked to extreme dental attrition, both pelvic indices are on an average practically alike in the series of the younger and in that of the older specimens. To be precise, the ischium-pubis index averages 101.5 in the former series and 101.8 in the latter and the relative pelvic inlet breadth averages 57.1 (52.1–68.7) and 58.0 (52.7–63.7) respectively, in the same series.

For the species, measured by the author, which are each represented by at least 30 specimens of males and females, the standard deviations, variation coefficients and the probable errors have been calculated for both pelvic indices. These data are listed in table 3. Judging by the variation coefficients, the ischium-pubis index is generally more variable in the great apes than in the macaque, gibbon and man, a distinction which is not clear-cut in regard to the relative pelvic inlet breadth. In the 5 female and 5 male series for which the variation coefficients were obtained for both pelvic indices, these coefficients average 5.80 in the ischium-pubis index and 5.57 in the relative pelvic inlet breadth, indicating that the latter proportion is slightly less variable than the former, a conclusion supported also by the respective ranges of variation (table 2) in a majority of the cases.

The relative size of the sex differences in these pelvic indices and the degrees of their reliability for determining sex in the different species are apparent from the figures in table 4, which are based on the data in table 2. The first two columns show the differences between the averages for adult

TABLE 3

Standard deviations, variation coefficients, their probable errors, and probable errors of the means (listed in table 2) for the ischium-pubis index and the relative pelvic inlet breadth in the larger series of primates used in the previous tables. The data by Washburn ('48) are marked by asterisks

SPECIES	SEX	ISCHIUM-PUBIS INDEX			RELATIVE PELVIC INLET BREADTH		
		P.E. (M)	$\sigma \pm$ P.E.	V $\pm$ P.E.	P.E. (M)	$\sigma \pm$ P.E.	V $\pm$ P.E.
Macaca mulatta	♀	0.60	5.68 $\pm$ 0.42	5.94 $\pm$ 0.44	0.38	3.62 $\pm$ 0.27	6.10 $\pm$ 0.45
	♂	0.51	4.02 $\pm$ 0.36	4.85 $\pm$ 0.44	0.37	2.90 $\pm$ 0.26	5.49 $\pm$ 0.49
Hylobates lar	♀	0.40	5.53 $\pm$ 0.28	5.44 $\pm$ 0.28	0.22	3.21 $\pm$ 0.16	5.58 $\pm$ 0.28
	♂	0.28	4.17 $\pm$ 0.20	4.50 $\pm$ 0.21	0.24	3.46 $\pm$ 0.17	6.59 $\pm$ 0.33
Orang-utan	♀	0.88	6.67 $\pm$ 0.62	6.23 $\pm$ 0.58	0.27	2.07 $\pm$ 0.19	4.83 $\pm$ 0.45
	♂	0.87	6.35 $\pm$ 0.62	6.49 $\pm$ 0.63	0.30	2.15 $\pm$ 0.21	5.97 $\pm$ 0.58
Chimpanzee	♀	0.68	5.50 $\pm$ 0.48	6.32 $\pm$ 0.55	0.31	2.46 $\pm$ 0.22	6.00 $\pm$ 0.53
	♂	1.03	6.99 $\pm$ 0.73	8.46 $\pm$ 0.88	0.36	2.44 $\pm$ 0.25	6.61 $\pm$ 0.69
Gorilla	♀	1.38	7.92 $\pm$ 0.97	8.06 $\pm$ 0.99			
	♂	0.78	5.89 $\pm$ 0.55	6.29 $\pm$ 0.59			
Negro	♀	...	4.6*	4.8*	0.34	1.60 $\pm$ 0.24	3.23 $\pm$ 0.49
	♂	...	4.0*	5.0*	0.36	2.36 $\pm$ 0.25	5.35 $\pm$ 0.57
White	♀	...	5.1*	5.1*			
	♂	...	4.0*	4.8*			

females (invariably the larger averages) and for adult males in *percentage* of the *latter* averages. The third and 4th columns give the numbers of individuals, females and males, within the range of variation common to both sexes, in *percentage* of the *total* number of cases available for the respective species. The ischium-pubis index has its largest sex

TABLE 4

*Differences between the averages for females and for males in percentage of the average for males are listed in the first two columns and percentages of cases within range of variation in the opposite sex are listed in the last two columns. Figures based upon data by Washburn ('42 and '48) are accompanied by asterisks*

SPECIES	ISCHIUM- PUBIS INDEX	RELATIVE PELVIC INLET BR.	ISCHIUM- PUBIS INDEX	RELATIVE PELVIC INLET BR.
<i>Ateles geoffroyi</i>	12.1	7.2	17	0
<i>Macaca mulatta</i>	15.4	12.3	25	33
<i>Macaca irus</i>	25.0*	...	0*	..
<i>Trachypithecus pyrrhus</i>	27.5*	...	0*	..
<i>Presbytis rubicunda</i>	33.8*	...	0*	..
<i>Nasalis larvatus</i>	12.2	9.6	0	36
<i>Hylobates lar</i>	9.6	6.5	55	82
<i>Hylobates moloch</i>	13.8	4.8	39	76
Orang-utan	9.4	19.2	44	4
Chimpanzee	5.3	11.1	82	60
Gorilla	5.0	13.6	90	0
Negro	18.9*	12.2	17*	27
White	19.0*	...	9*	..

differences in the three species of monkeys studied by Washburn, in which the difference between females and males equals anywhere from one-fourth to one-third of the average value for males and in which there is no overlapping of the ranges of variations of the two sexes. In all the other species the sex difference in the ischium-pubis index is relatively much smaller and only in the proboscis monkey is there no overlapping in the values for individual males and females. Decidedly the least marked are the sex differences of this index

in the anthropoid apes,<sup>4</sup> in all of which there is also the most extensive overlapping of the ranges of variation for females and for males. The smallest of all the sex differences are found in the African apes, in which the differences between the two average values amount to only 5.0 and 5.3% of the averages for males and 82 to 90% of the individual indices share the same range of variation. In chimpanzees and gorillas, therefore, the relative length of the pubic bone is practically useless for diagnosing sex. In orang-utan and gibbon the sex differences in the ischium-pubis index are clearly more marked, though much less pronounced than in monkeys and man.

The relative pelvic inlet breadth has comparatively the largest sex differences in the great apes, the macaque and the Negro, and the relatively smallest sex differences in the spider monkey and the gibbons, according to the data in the second column of table 4. As shown by the percentages in the last column of table 4, this relative inlet breadth is separated in the two sexes with the least amount of overlapping in spider monkey, gorilla, orang-utan, and Negro, but in the other primates listed this overlapping is extensive, and in gibbons and chimpanzees decidedly too much so to regard this index as serviceable in sex determinations.

A comparison between the data for the ischium-pubis index and those for the relative pelvic inlet breadth in table 4 permits the conclusion that sex differences of the former proportion are more marked and reliable than those of the latter proportion in at least two of the three species of monkeys, the two species of gibbons and the Negroes, but that the reverse condition exists in all three great apes. It can furthermore be concluded that pelvic sex differences in one or the other of these indices develop in adults of all these primates, but in widely different degrees in the various species. Consid-

<sup>4</sup> The marked sex difference in this index in the small series of *Hylobates moloch* is, naturally, not as significant and reliable as the small sex difference in this index found in the very much larger series of *Hylobates lar*.



ering all the data, it can be stated that in gibbons and chimpanzees the pelvis shows the least significant sex differences.

RELATIVE SIZE OF NEWBORN AND ITS INFLUENCE  
ON THE FEMALE PELVIS

In attempting to explain the striking differences in the degrees of pelvic sex differentiation among adult primates the following two possible influences have to be considered: (1) Any enlargement in the pelvic ring of the female may be a

TABLE 5

*The average weight of newborns in percentage of the average weight of adult females. The figures for Cebus, Pygathrix, Nasalis, and Gorilla are tentative, being based on very few birth weights. The figure for man is a rough average, calculated from data in the literature*

SPECIES	PERCENTAGE
Ateles geoffroyi .....	7.0
Cebus capucinus .....	8.5
Macaca mulatta .....	6.7
Pygathrix cristatus .....	7.0
Pygathrix entellus .....	6.7
Nasalis larvatus .....	4.6
Hylobates lar .....	7.5
Orang-utan .....	4.1
Chimpanzee .....	4.0
Gorilla .....	2.4
Man .....	5.5

necessary requirement for the successful passage of the newborn, and represent the result of natural selection. (2) Sex differences in the pelvis may be an integral part of general secondary sex differentiation, affecting among primates, as is well known, a great variety of bodily structures, and this in widely different degrees in different species. Neither of these possibilities conflicts in the opinion of the author with his conviction that pelvic sex differences, as those in all other parts of the body, stand under endocrine control.

The topographic conditions of the pelvic ring can be very different in various types of primates, as has already been

discussed at length in former papers by the author ('30, '36). Here it is merely recalled that in the monkeys the sacrum, which is usually composed of only three short vertebrae, lies high above the pubic symphysis, whereby the act of birth is much facilitated. In the great apes the lumbo-sacral border also lies far above the ventral part of the pelvic ring, but

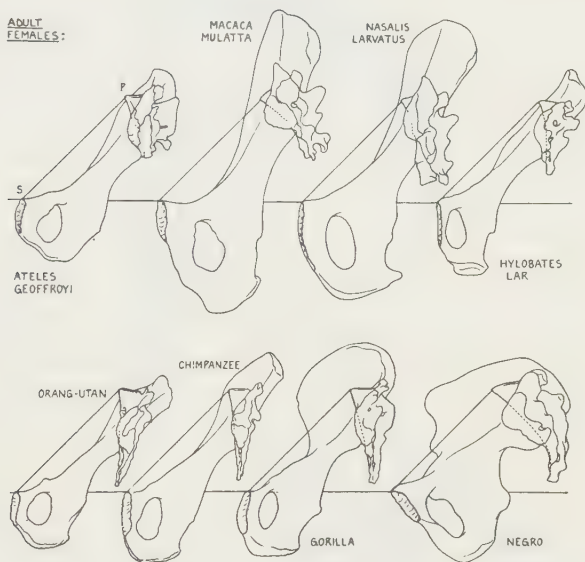


Fig. 1 Side views of right hip bone and articulated sacrum in some adult female primates, drawn with dioptrograph, projected on sagittal plane. All drawings are reduced to the same symphysis-promontorium diameter ( $= S - P$ ) which has been arbitrarily inclined at an angle of  $45^\circ$  with a horizon through the symphysis.

the sacrum, consisting of 5 or more vertebrae, reaches relatively farther down toward the level of the symphysis than it does in monkeys. In man these conditions have become extremely changed, together with the extensive shortening and bending of the iliac bones, and the entire sacrum has moved to a position directly opposite, rather than far cephalic of, the pubic symphysis. In passing between the maternal pubic and ischial bones the head of the full-term fetus has already moved below the sacrum in monkeys, it is only partly hemmed

in by the slender, caudal end of the sacrum in the great apes, but it encounters the full dorsal restriction of the broad sacrum in man. These conditions are illustrated by the exact drawings in figure 1, which have all been reduced to the same

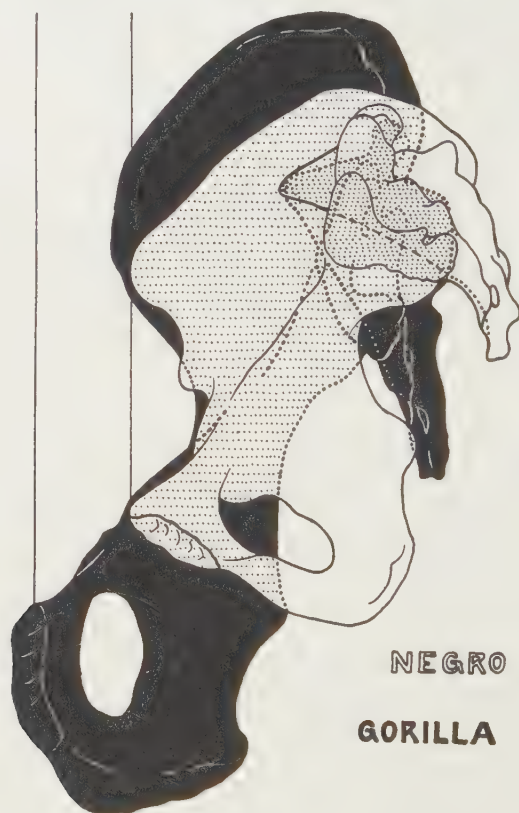


Fig. 2 Side views of right hip bone and articulated sacrum in an adult female gorilla and an adult female Negro, both reduced the same proportionate amount and posed in relation to the longitudinal axis of the trunk (indicated by the two perpendicular lines). The drawings are superimposed so that the promontorium points coincide.

symphysis-promontorium distance and posed in the same, arbitrarily chosen, direction. It is seen that, generally speaking, the pelvic topography of the gorilla is least removed from that of man, though there is still a very significant gap

between these two primates. This is particularly evident if the outlines of the pelves of gorilla and man are superimposed with the same proportionate reduction and with natural orientation, as has been done in figure 2, which also shows the

TABLE 6

*Averages of the absolute size of the diameters of the pelvic inlet in adult females and averages of the absolute size of head length, head breadth and shoulder breadth in newborns according to the author's data. The figures for newborn gorilla are only estimates derived from data for a large fetus and for three small infants.<sup>1</sup> N. B. The head length was measured from the glabella and the shoulder breadth between the acromial points*

SPECIES	ADULT FEMALES			NEWBORNS			
	Specimens	Pelvic inlet breadth	Symphysion—Promontorium	Specimens	Head length	Head breadth	Shoulder breadth
Ateles geoffroyi	7	54.4	90.3	8	66.9	52.2	50.4
Macaca mulatta	41	50.9	67.7	28	66.3	50.7	49.2
Nasalis larvatus	15	51.8	71.5	1	64.0	49.0	59.0
Hylobates lar	87	55.9	78.7	6	64.2	52.7	51.2
Orang-utan	26	102.5	149.6	4	84.1	74.9	81.8
Chimpanzee	29	98.0	149.5	9	83.0	71.0	84.9
Gorilla	10	122.6	175.7	4	97.0	79.0	92.0
Negro	10	121.6	112.9	10	123.8	98.5	118.3

<sup>1</sup> Since nobody has as yet measured a newborn gorilla, the following data were used for estimating the two head diameters and the shoulder breadth of the gorilla at birth: Babor and Frankenberger ('31) have described the largest gorilla fetus on record, a specimen weighing 1310 gm and, judging by the state of its development, not far from term. Its head length measures 91 mm, head breadth 75 mm and shoulder breadth 83 mm. The three youngest gorilla infants, measured by the writer, have all their deciduous incisors and first molars fully out, but no other teeth. This particular stage of dental development is not reached before the sixth month in chimpanzees and it is most unlikely that it should be attained at an earlier age in gorillas. In these three infants the head length averages 119.3 mm, the head breadth 96.7 mm and the shoulder breadth 128.0 mm. It is certain that at birth these measurements would be very much nearer to their values in the large fetus than to their size in these infants, probably at least 5 months old. It is reasonable, therefore, to assume that at most one-fifth of the difference between the corresponding measurements of the fetus and of the infants could have been added at birth to the size of the fetus referred to here. The estimated values for the newborn gorilla in table 6 equal the actual measurements of the fetus + 20% of the increases in these measurements to their average values in the infants.

striking "telescoping" in the human pelvis. From these observations it can be concluded that the size of the sagittal diameter of the pelvic inlet is not nearly of as vital importance during parturition in monkeys as it is in man. The latter is the only primate with a sagittal diameter of the pelvic inlet (symphysion-promontorium) as short as, and often even shorter than, the transverse diameter (see table 6).

After these introductory remarks the question can be considered to what extent especially the transverse diameter of the pelvic inlet may be influenced by the requirements for the passage of the newborn. This transverse diameter is closely dependent upon the length of the pubic bone and, of course, is directly measured by the pelvic inlet breadth, so that both the pelvic indices used here are expressions of the relative size of the pelvic inlet in a transverse direction.

The data in table 5 demonstrate that, as a rule, monkeys and gibbons have larger babies in relation to the size of the mothers than have the great apes. Man occupies an intermediate position in this respect. There appears to be little direct correlation between these findings and the various degrees of pelvic sex differences in the corresponding primates, as listed in table 4. In view of the fact that the proportionate general size of the pelvis is not at all constant among different primates, it is necessary to study also the relation between the size of the inlet of the adult female pelvis and those dimensions of the newborn which are of greatest significance during the act of birth. The data for such comparisons have been compiled in table 6 and have been used for the construction of the diagrams in figure 3, which serve to illustrate the relation in size between the maternal pelvic inlet and the main head- and shoulder-diameters of the newborn. From this table and, more clearly and conveniently, from figure 3 it is apparent that there is an amazingly small difference in size between the diameters of the adult pelvic inlet and those of the head of the fetus at full term in monkeys, gibbons and man, i.e., in the species <sup>5</sup> with comparatively large newborns according to table 5. Individually this relation in size between the head of the newborn and the maternal pelvis can probably vary just as much in monkeys as it has been found to vary in man (Riggs, '04). In the great apes, which are distin-

<sup>5</sup> The exceptionally small relative birth weight in *Nasalis*, as given in table 5, may not be typical for that species. It is the percentage relation between a single record for a newborn and the average of the weights of 15 adult females which varied between 8.2 and 11.8 kg.



guished by having comparatively small newborns, the pelvic inlet of adult females is strikingly larger than the head and the shoulder breadth of newborns.

These surprising findings that the pelvic ring seems to be unnecessarily wide in all great apes, while barely permitting

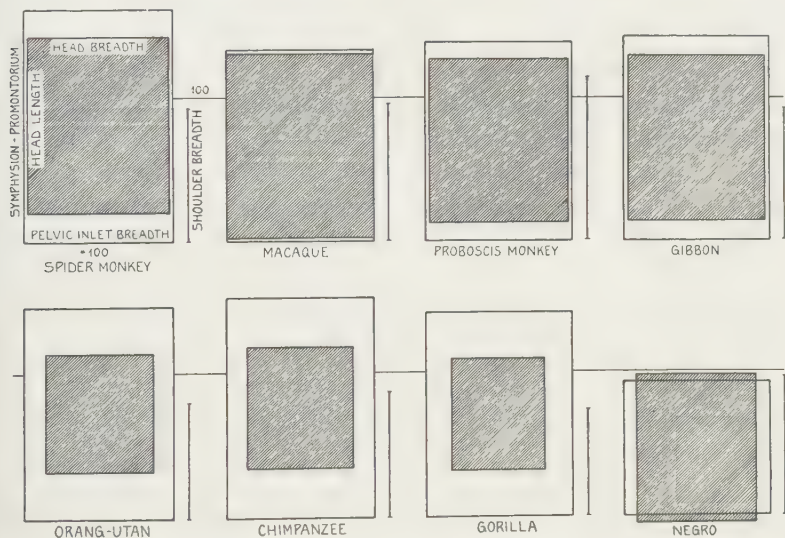


Fig. 3 Diagrammatic representation of the relation in size between the average diameters of the pelvic inlet in adult females and the average head length, head breadth and shoulder breadth of newborns of the corresponding species, constructed from the data in table 6 after these had been calculated in percentage of the pelvic inlet breadth.

the delivery of the newborn in the other primates,<sup>6</sup> cannot readily and consistently be correlated with the degrees of pelvic sex differentiation in adults. In all the monkeys studied so far, and in man, the proportionate length of the pubis and the relative breadth of the pelvic inlet become significantly increased after sexual maturity in females and for all these

<sup>6</sup> In macaques labor is usually a prolonged, very difficult and exhausting process according to the many detailed and careful observations of Tinklepaugh and Hartman ('30). In chimpanzees, on the other hand, Yerkes ('43) found that: "Birth mother or infant." Of an exceptionally large newborn chimpanzee, weighing 1900 gm, Egg ('45) reports that its birth was "quick and easy."

primates it can be claimed that this enlargement represents a very essential adaptation in view of the proportionately large size of their newborns.<sup>7</sup> Gibbons, however, also give birth to very large babies, but show comparatively small pelvic sex differences. In the great apes, in which the small size of the fetus at term would not necessitate any enlargement in the female pelvis, the ischium-pubis index differs very little in the two sexes, but the relative pelvic inlet breadth is very significantly larger in females than in males in the orang-utan and the gorilla. If it is assumed that the pelvic sex differences of primates are the necessary result of the disproportionately large size of the head of the newborn, the exceptions to this rule, found in the anthropoid apes, remain to be explained.

#### SECONDARY SEX DIFFERENCES IN GENERAL AND THOSE IN THE PELVIS

It seems perfectly justifiable to regard any sex difference in the pelvis as merely one of many possible manifestations of general secondary sex differentiation and as developing independent of any requirements for parturition. How very widely the degrees of general sex differentiation can differ among primates is shown, e.g., by the percentage relations between the average body weights of females and of males which have been listed in table 1 (column *A*). In gibbons the sexes are nearly alike in body weight and no other marked secondary sex differences have been found, not even in the canines.<sup>8</sup> This unusual, great similarity of the sexes in gib-

<sup>7</sup> In the rhesus monkey, e.g., for which the author could measure an extensive series of excellent specimens (largely from the Carnegie colony of macaques), the head diameters of the newborn practically equal the diameters of the maternal pelvic inlet and actually surpass the average diameters of the pelvic inlet in adult males. Birth molding of the head in the macaque must reduce length and breadth while increasing head height.

It may be mentioned in this connection that widening of the birth canal is possible to a limited extent in consequence of some relaxation of the pelvic ligaments during the later stages of pregnancy not only in man, but also in macaques (Hartman and Straus, '39) and, possibly, other primates.

<sup>8</sup> In *Ateles*, in which males and females also have very similar body weights, the canines of the former are very much larger than those of the latter.

bons may be connected with the same factors which also inhibit the sex differentiation in the pelvis of this anthropoid. The conditions in the great apes lend support to this hypothesis. In orang-utans and gorillas adult males weigh on an average twice as much as adult females (see table 1) and there are many other very profound secondary sex differences in cranial and dental characters, hair, etc. The marked sex difference in the relative pelvic inlet breadth, found in both these apes in which they are not needed for parturition, may persist simply on account of the very marked trend for divergent development of the two sexes. In chimpanzees the pelvis is not very clearly differentiated according to sex, and the individual variations of the pelvic indices overlap extensively in males and females (table 4). It is very significant in this connection that it is the chimpanzee which contrasts sharply with orang-utans and gorillas in having exceptionally few and comparatively small secondary sex differences in other parts of the body, besides the pelvis. The males of chimpanzee are but little heavier than the females, and lack such sex characters as cheek pads and huge cranial crests. Even the sexual distinction in the size of the permanent canine teeth is not nearly as marked and constant in chimpanzee as in orang-utan and in gorilla. This is shown, e.g., by the data in table 7, according to which there is no overlapping of variations in the thickness of the upper canines in males and in females of the latter two apes, but very considerable overlapping in chimpanzee.

On the basis of these observations it can be concluded that a comparatively long pubic bone and wide pelvic inlet characterizes adult females of species with proportionately large newborns (especially in relation to the size of the pelvis), except in the case of the gibbon. In many instances, therefore, the requirements for successful parturition can be regarded as selective factors responsible for the development of a relative widening of the birth canal in the adult female. A corresponding widening, however, exists also in females of orang-utans and gorillas which have pelves amply large for

the passage of their relatively small babies. These apes are distinguished by having very marked secondary sex differences in a considerable variety of bodily features, whereas

TABLE 7

*The sagittal diameter of the upper canines in adult great apes according to the literature and the writer's new data on orang-utans. The measurements by Remane and by Hooijer refer to the antero-posterior diameter of the crown, but those by the author to the maximum sagittal diameter of the alveolus*

PRIMATE	SEX	SPECIMENS	AUTHOR	MEAN	RANGE
Orang-utan	♀	160 ♀ + ♂	Remane, '21	...	10.6-13.9
	♂			...	14.3-20.9
Orang-utan	♀	23	Hooijer, '48	12.9	11.7-15.0
	♂	17		18.3	15.4-21.8
Orang-utan	♀	5	Schultz,	10.8	10-12
	♂	10		19.0	17-21
Chimpanzee	♀	287 ♀ + ♂	Remane, '21	...	10.1-15.4
	♂			...	12.3-16.5
Chimpanzee	♀	10	Schultz, '48	11.0	9-13
	♂	15		14.7	11-17
Gorilla	♀	322 ♀ + ♂	Remane, '21	...	13.3-17.2
	♂			...	18.0-25.5
Gorilla	♀	10	Schultz, '48	13.4	11-15
	♂	25		20.6	18-25

gibbons and chimpanzees with their small pelvic sex differences show exceptionally little general sex differentiation. It appears, therefore, that a strong tendency toward numerous and diverse sex differentiations includes at least some pelvic sex differences, even if not needed for the act of birth, and that the scant development of all or most secondary sex char-



acters can hinder also the formation of marked pelvic sex differences, regardless of a need for such.

#### SUMMARY

This paper deals chiefly with two pelvic proportions in male and female primates measured by the author. Nine different species are represented by material consisting of approximately 460 adult specimens and of 26 sub-adult specimens in which sex is either definitely known or, in a few instances, could be determined with certainty. The proportions investigated are the length of the pubis in percentage of the length of the ischium, and the breadth of the pelvic inlet in percentage of the greatest pelvic breadth. The author's findings for the former index can be compared with corresponding data for three species of monkeys and two races of man, published by Washburn.

Among all the adult primates the ischium length is, on an average, larger in males than in females of the same species, but the pubis length and the pelvic inlet breadth is larger in females than in males in at least those species in which total body size is not extremely different in the two sexes.

The averages as well as the extreme variations of the ischium-pubis index and of the relative pelvic inlet breadth are larger in adult females than in adult males of all the species investigated. This, however, is not yet the case among the sub-adult specimens. After adulthood these indices do not change any more with age, at least in the gibbon. The relative pelvic inlet breadth is in general somewhat less variable than the ischium-pubis index. Sex differences in the ischium-pubis index are very marked in monkeys and in man, much less marked in gibbon and orang-utan, and barely indicated in chimpanzee and gorilla. The relative pelvic inlet breadth shows the greatest sex differences in orang-utan and gorilla, somewhat smaller differences in monkeys and man, and comparatively the smallest differences in gibbons. In chimpanzee this index has a considerable sex difference in its averages,



but varies individually with very extensive overlapping of the sexes.

The sagittal and transverse diameters of the inlet of the adult female pelvis are very little larger than the head diameters of newborns of the corresponding species in monkeys, gibbons and man. In the great apes these pelvic diameters surpass the head diameters of newborns by surprisingly large amounts. The widening of the female pelvis represents a vital adaptation to the requirements of parturition in monkeys and in man, but not in the anthropoids. In the pelves of orang-utans and of gorillas the relative inlet breadth is larger in females than in males even though it is amply large (in both sexes) to permit the easy passage of the fetus at term. In gibbons, which have relatively large newborns, and in chimpanzees, which have proportionately small newborns, the pelvic sex differences are poorly developed. Among the anthropoid apes, therefore, the amount of specialization in the female pelvis does not correspond to the relative size of the fetus at birth; it is, however, closely correlated with the general trend for sex differentiation in other bodily parts, which is extremely well marked in orang-utan and gorilla, but unusually little developed in gibbon and chimpanzee.

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EXPLANATION OF THE PYGMIES.—There are as a *race* no pygmies in Melanesia but only peoples of small stature, resembling very much the peoples of normal stature. This makes it very probable that the so-called pygmies in other parts of the world are *not* real pygmies but merely modifications of the people of normal stature caused by the influence of the mode of life and of nutrition. This theory is [based on] the fact that the “Pygmies” have nowhere their own language and that in their culture there is nothing separating them from other “parasitic-living” peoples of normal stature. —Felix Speiser. *Die Pygmäenfrage*. *Experimentia*, vol. 2, no. 8, 1946, 16 pp.

EXPLANATION OF THE POLYNESIANS.—There is no proof that the Polynesian language contains Indo-Germanic words.

We are certain that the Proto-Polynesian culture arose in the region of Formosa-Celebes-Philippines.

The similarity between Polynesian and European mythology is explained by an Asiatic center of diffusion.

The present Polynesian culture is composed of a mixture of 2 elements: (1) Proto-Polynesian; (2) Austro-Melanesian, a mixture which took place only in Polynesia.

The Polynesian race shows no trace of a European element. No anthropological argument [to the contrary] withstands a careful examination.

The existence of a light-haired group among the Polynesians is not proved.

The Polynesians were originally pure Mongoloids.

They mixed in Polynesia with the Austro-Melanesians, but the Polynesian element predominates.

One still finds a great number of Proto-Polynesian types in eastern Asia.—Felix Speiser. *Les Polynésien sont-ils des Aryens?* *Arch. Suisses d'Anthrop. Gén.*, tome 12 for 1946, 1947, pp. 68–91.

## SEX DIFFERENCES IN THE PUBIC BONE OF BANTU AND BUSHMAN

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### TWO FIGURES

The determination of the sex of skeletons has always been a matter of importance to the anthropologist. Traditional methods, involving many measurements, indices, and observations (Martin, '28; Stewart, '47), are cumbersome and frequently unreliable (Hooton, '46). A simple method which will determine the sex of the majority of skeletons is based on the ischium-pubis index (Washburn, '48). The pubic bone of the adult female is longer than that of the male. On the other hand, the male ischium is longer than that of the female. The ischium-pubis index ( $\frac{\text{pubis length} \times 100}{\text{ischium length}}$ ) takes advantage of these relations, and proved to be an efficient indicator of sex when tested on 300 skeletons in the collection of the Hamann Museum of Anatomy and Comparative Anthropology of Western Reserve University. Well over 90% of this sample of American Whites and Negroes could be sexed using the ischium-pubis index alone. The question naturally arises whether sex differences of this order exist in all human races. Schultz ('49) has shown that the degree of sexual differentiation varies greatly among non-human primates.

An opportunity to continue studies on the nature and degree of sexual differentiation in the pelvis was afforded by a trip to South Africa, made possible by a generous grant from the Viking Fund. The magnificent collection of Bantu skeletons at the University of the Witwatersrand forms the basis for this study. These skeletons are of known tribe and

sex and were prepared in the Anatomy Department under the Direction of Professor Dart. The Bushman series is pieced together from collections at the museums in Cape Town, Kimberley, and Pretoria, and the Anatomy Departments of the Universities of Cape Town and the Witwatersrand. These skeletons were largely from archaeological excavations. They afforded an opportunity to test the ischium-pubis index on a different race and on specimens of unknown sex. It is hoped that the data on both Bantu and Bushman will add to our knowledge on the nature and degree of sex differentiation of the human pelvis, and that analysis of the Bushman series will show the utility of the ischium-pubis index as an indicator of sex, even when applied to archaeological specimens belonging to a race not previously studied by these methods.

The writer wishes to express his thanks to Professor R. A. Dart of the University of the Witwatersrand, Professor M. R. Drennan of the University of Cape Town, Dr. K. H. Barnard, Director of the South African Museum, Mr. J. H. Power, Director of the McGregor Museum, and Dr. V. FitzSimons, Director of the Transvaal Museum, for permission to study the collections in their institutions. Further thanks for kindness and friendly help are due to Dr. R. Broom, Dr. O. S. Heyns, Mr. J. T. Robinson, Miss M. Shaw, and Dr. L. H. Wells.

#### MATERIALS AND METHODS

The number of cases; the means for length of pubis and ischium-pubis index, and width of sciatic notch, and the range, standard deviation, and coefficient of variation for each, are listed in table 1. The Bantu males are all Basutu and Zulu. In order to get enough females for comparison, it was necessary to include individuals from a wide variety of South African tribes. However, the variation in the female sample is no greater than that in the male, so the South African Bantu may be regarded as a single population as far as these measurements and proportions are concerned. The Bushman series is much more heterogeneous and, probably, includes at least



three or four Hottentots. The two skeletons upon which Broom based his idea of a Korana type are included (Broom, '41; Wells, '48).

The locations of the measurable pelves are as follows: University of Cape Town, 14; South African Museum, 13 (all from graves at Colesberg; Slome, '29); McGregor Museum, 15 (11 excavated at Koffiefontein); Transvaal Museum, 5; and University of the Witwatersrand, 8. Three or 4 individuals

TABLE 1

*Length of pubis and ischium in mm, ischium-pubis index, and sciatic notch width*

	PUBIS LENGTH					ISCHIUM LENGTH			
	No.	Mean	Range	S.D.	C.V.	Mean	Range	S.D.	C.V.
Bantu									
Male	82	66.2	(57-78)	4.5	6.8	80.3	(71-92)	4.5	5.6
Female	70	73.2	(66-84)	4.1	5.6	74.8	(68-84)	3.5	4.7
Bushman									
"Male"	26	60.4	(53-67)	3.5	5.8	72.2	(66-78)	3.4	4.7
"Female"	29	66.8	(60-76)	4.0	6.0	66.9	(61-76)	3.9	5.9
	ISCHIUM-PUBIS INDEX					SCIATIC NOTCH WIDTH			
	No.	Mean	Range	S.D.	C.V.	Mean	Range	S.D.	C.V.
Bantu									
Male	82	82.5	(70-91)	4.6	5.6	25.1	(17-38)	4.1	16.2
Female	70	98.1	(87-107)	4.1	4.2	35.0	(21-45)	5.4	15.3
Bushman									
"Male"	26	83.7	(76-91)	3.3	4.0	23.7	(19-35)	3.9	16.4
"Female"	29	100.0	(93-108)	3.9	3.9	34.9	(25-44)	5.4	15.4

are of known sex, but these form such a small percentage that the whole series has been treated as of unknown sex.

The measuring technique is that described by Schultz ('30). Length of pubis and ischium are taken from the point in the acetabulum where the three elements forming the innominate bone meet. Obviously, this point can be located only approximately in the adult. When there is doubt concerning the location of the point, both measurements should be taken as long as allowable within the definitions, which are discussed at greater length in an earlier paper (Washburn, '48). It is

important that the pubic bone be fully grown; that is, that the adolescent ridge and furrow formation described by Todd ('20) be lost.

The maximum width of the sciatic notch was measured. This measurement is particularly important in the present study because a wide notch is not only a female characteristic but is a racial feature of the Bushman, according to Orford ('34).

#### DISCUSSION

Sexual differences in the pelvis of Bantu and Bushman are pronounced and of the expected kind. The pubic bone of the females is longer than that of the males. Conversely, the male ischium is longer. Therefore, the ischium-pubis index is much higher in the females. The mean for the index of both Bantu and Bush females exceeds that of the males by approximately 16%, or nearly 4 times the standard deviation. The success with which the ischium-pubis index separates the males and females is most clearly shown in graphic form, in figure 1. Only three Bantu females fall in the range of male variation. The sex of only one Bushman skeleton is left in doubt.

The size of the sciatic notch is useful in assessing the sex of some of the doubtful cases. The notch is approximately 1 cm wider in the females than in the males. In spite of this great difference (the female exceeds the male by 40%), the variability of the notch is so great that it is much less reliable as an indicator of sex than the index. The mean coefficient of variation of the index is less than 5, while that of the notch is over 15. The extensive overlapping which this allows, in spite of the large difference in the means, is clearly shown in figure 2. However, the single Bushman pelvis which is intermediate with regard to the index has a notch width of only 21 mm, and therefore is almost certainly male. Even after considering the width of the notch, the sex of two of the Bantu pelvises cannot be determined.

The Bush pelvises are remarkable for their exceedingly large sciatic notches. The dimensions of the notch are practically

the same as those of the Bantu, although the Bantu far exceed the Bushman in every other dimension. These wide notches are a striking feature of the Bush pelvis, and are apparently

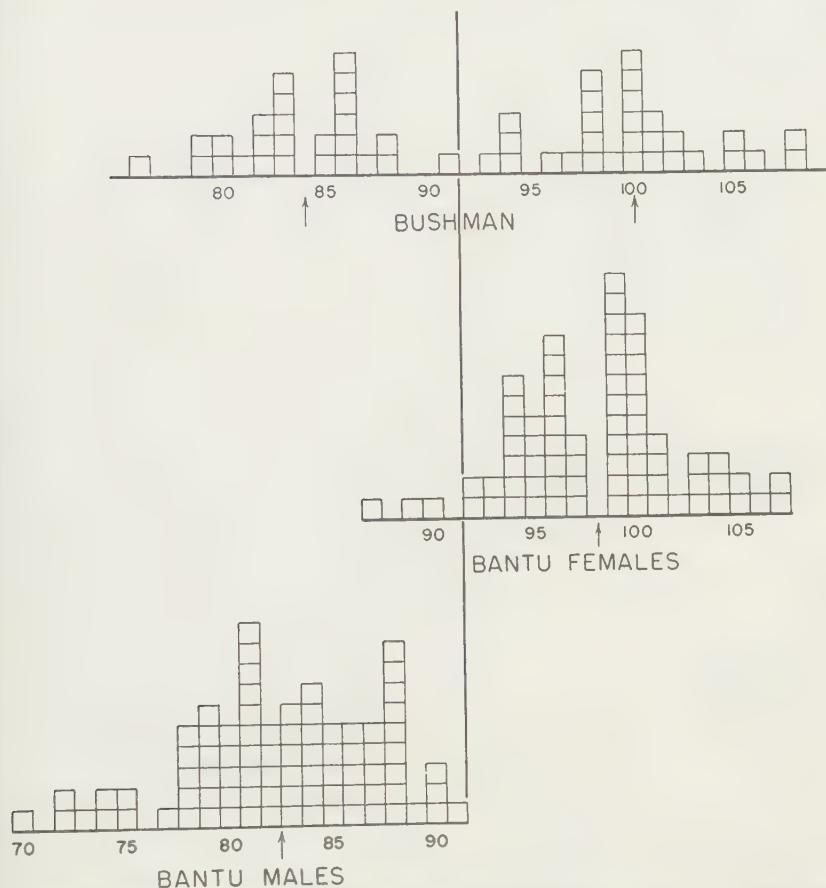


Fig. 1 The distribution of the ischium-pubis index in Bantu and Bushman. Arrows point to the means.

the main reason why Orford ('34) described the sexual differentiation in the Bushman as "exaggerated".

The degree of sexual differentiation in the ischium-pubis index is much the same as that previously described in American Whites and Negroes, i.e., 15 or 16%. However, the

means differ slightly in each population investigated, as listed below:

	MALE	FEMALE
American Negro	79.9	95.0
Bantu	82.5	98.1
American White	83.6	99.5
Bushman	83.7	100.0

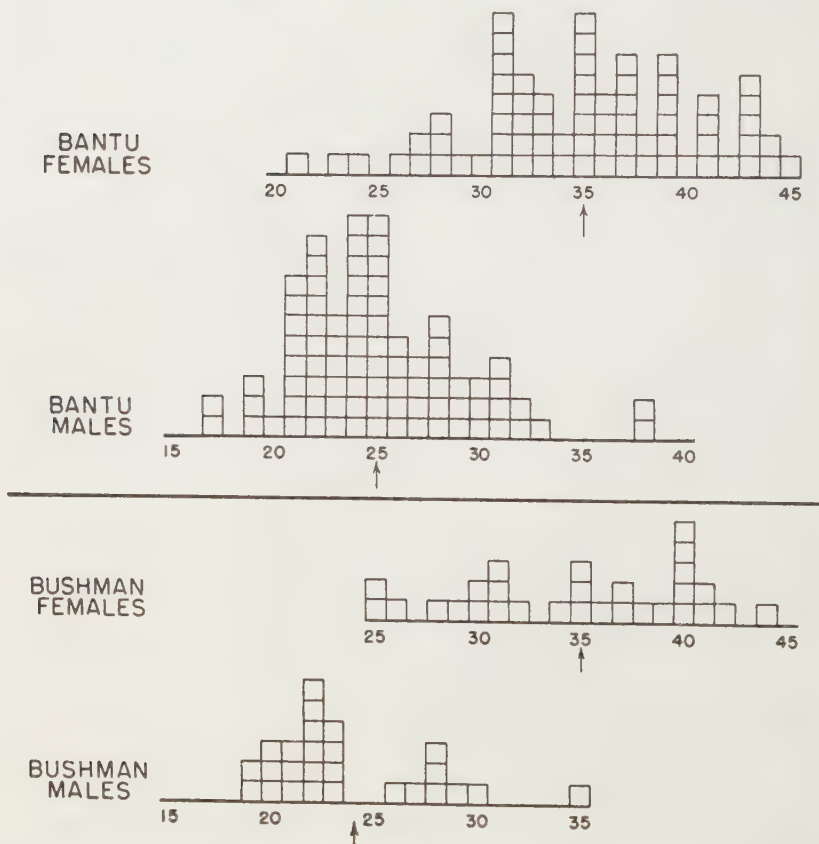


Fig. 2 Sciatic notch width in millimeters in Bantu and Bushman. Arrows point to the means.

American White and Bushman are nearly identical and Bantu little different. As far as the problem of predicting the sex of skeletons is concerned, one would certainly have to allow for differences of this order, even when working with samples

from a single population. The American Negroes are the most different, suggesting that West African populations may differ in this respect from those of East and South Africa. There is an indication of a gradient, indices of both males and females being lowest in West Africa, higher in East, and highest in the South. This supposes that the Bantu groups investigated came down from East Africa, as Dart ('37) has suggested. Obviously, such a cline could not be proved unless many more samples followed the same pattern. In general, racial differences are much less clearly marked than they seemed when data on American Whites and Negroes only were available. This is an advantage from the point of view of predicting sex, because the closer the means of different populations, the less standards will have to be changed from one area to another.

#### SUMMARY

1. The purpose of this paper was to investigate the sexual differentiation of the pubic bone of Bantu and Bushman, as measured by the ischium-pubis index, and to test a method of determining the sex of human skeletons.

2. Length of pubis, length of ischium, and width of sciatic notch were measured in 152 skeletons of Bantu of known tribe and sex, and in 55 Bushman skeletons, mostly from excavations.

3. The ischium-pubis index was calculated, and the females were found to exceed the males by approximately 16%, or by nearly 4 times the standard deviation of the index.

4. The sciatic notch averaged 1 cm wider in the females.

5. The sex of the majority of the skeletons could be determined by the index alone, and part of the remainder by the notch. Using both the index and the notch, the sex of over 98% of the skeletons could be determined.

6. Sex differences are of the same order as those previously reported for American Whites and Negroes.

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ANTHROPOLOGY OF MOZAMBIQUE.—In 1945, under the authorship of J. R. Dos Santos Júnior, there appeared a French-English summary of his large volume “Contribuição para o estudo da antropologia de Moçambique—algumas tribos do Distrito de Tete,” published by the Board for Geographical Missions and Colonial Investigations (Junta das Missões Geográficas e de Investigações Coloniais). This work, printed in Oporto in 1944, comprises 416 pages, 204 figures, 73 plates and 12 tables. The tables give the individual measurements on 120 male and 46 female Nhúngüês, 29 male Antumbas, 20 male and 20 female Chucundas, 27 male Sengas, 31 male Sêrêros, 20 male and 20 female Atandes, 31 male Tauaras, and 10 male Demas.

## CONSTITUTION IN FEMALE OBESITY

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TWENTY-FOUR FIGURES

Who gets fat? What social roles and physical and temperamental peculiarities distinguish the fat white woman in modern American society? How far can anthropology illuminate the causes of obesity?<sup>1</sup>

The answers to these questions are far from irrelevant. Stieglitz ('47) rates obesity more critical to national health than undernutrition. The fat person suffers from a really dangerous chronic syndrome. Evans ('47) quotes life insurance statistics from Preble and others to show that the death rate is doubled in people as obese as the sample studied here, and is raised strikingly even in people 10% overweight. Dublin and Lotka ('36, p. 280) point out that in the middle-aged group a 25% increase in weight means a 25% decrease in life expectancy. This abbreviation of life Evans ('47), Gastineau

<sup>1</sup>The data reported here were gathered as part of a research program in constitution in the Endocrine Clinic of the Jefferson Medical College. Obesity was chosen as a subject for joint research not simply because of its relation to health and length of life but also because of its interest from many angles: psychological, social anthropological, physiological, and genetic as well as medical. Patients were studied from medical and endocrine standpoints by Dr. Karl E. Paschkis, from the psychiatric standpoint by Dr. Robert A. Matthews, Dr. Robert Schopbach, and Dr. Albert Kaplan, with collaboration in important phases of the problem by Dr. Paul Swenson (Department of Radiology). The present study covers only anthropological aspects of the problem. A report correlating all aspects examined is forthcoming.

For advice and criticism I am deeply indebted to Dr. C. W. Dupertuis, Dr. R. A. Matthews, Dr. Karl E. Paschkis, Dr. H. B. Richardson, Dr. T. Sohler, and Dr. P. Swenson. Errors and bias, however, are entirely my own responsibility.

and Ryneerson ('47), and others attribute to degenerative diseases in general: hypertension, cardiovascular-renal breakdown, cerebral haemorrhage, diabetes, cirrhosis, cholecystitis, as well as increased surgical risk. It is not surprising that Evans considers that an end of this waste would be a great advance in (preventive) medicine. But it is not at all clear how far this increased disease and death rate is a simple result of excess fat rather than a complex accompaniment of the obese constitution. The present study may indirectly clarify this point. But what is clear at the start is that, with 10-15% of middle-aged males and more than twice that proportion of females in the U. S. A. suffering from obesity, the relative rarity of obesity after the age of 60 is a sufficient proof of the physiological inefficiency of the obese as a group. This, of course, does not mean that the obese person may not flourish in a socially useful position in which the physiological handicap is minor.

Contrary to a widespread misconception, endocrine factors play a negligible role in the fat accumulation of the vast majority of obese individuals (K. Paschkis, personal communication; Bruch, '39a, '40b, '41; Evans, '47; Gastineau and Ryneerson, '47; Newburgh and Conn, '44).

Obesity results from a positive energy balance following a relatively increased ingestion of food without any discoverable increase in efficiency of food absorption (Bruch, '39b; Evans, '47; Newburgh and Conn, '44; and Rony, '40). But why the increased eating? In mammals in general there is a very sensitive and accurate psycho-physiological balance between change in activity and energy use and change in appetite and food eaten. A sudden decrease in daily activity will not normally produce chronic obesity since appetite will slacken. Hence it is this appetite satiety adjustment of the obese which is disturbed, at least at the time when they are gaining weight. And the research of Bruch ('40b, '41, and '47) and Bruch and Touraine ('41) on children and of Rennie ('40), Gray ('43), and Richardson ('46) on adults, have shown that obesity in a person follows environmental stress

or restriction. The potentially fat person responds to socially derived tension, anxiety, insecurity feelings, or depression, by overeating. There is an increased appetite and often a neurotic craving for oral satisfaction and food. Bruch ('40b) finds lack of exercise and lessening of extra-gustatory activity in general among fat children. And this appears to be equally true of adults. Thus the positive energy balance of the obese is increasingly accepted by modern medical opinion as part of a psychosomatic syndrome linked with increased appetite.<sup>2</sup> And overeating in response to stress (or to social tradition) is a neurotic reaction of temperament and personality.

But why should other people respond to similar pressures and difficulties of their social environment by taking refuge in one of the following: a psychosis, an anxiety neurosis, alcoholism, gastric ulcers (Draper, Dupertuis, and Caughey, '44, pp. 206-238; Wolf and Wolff, '42; and Richardson, '45), anorexia nervosa with emaciation (Richardson, '45), hyperthyroidism (Conrad, '34), excessive aggression, or even accidental fracture (Dunbar, '43); or by such "healthy" responses as increased realistic effort, hobbies, or artistic creation?

Draper ('24, '44), Dupertuis, and others have shown such clinical groups to be marked by physical as well as temperamental distinctions. Hence it is logical to look for the sources of these different responses not only in biographical differences but also in differences in individual constitution as determined by heredity plus the organism's earliest responses to intrauterine and infant environment. Studies of twins by such investigators as Newman, Freeman and Holzinger ('37, pp. 131-359, table 96) show heredity to play a dominant role in physical constitution except for body weight, which, like psychological makeup, is still sufficiently influenced by heredity so that a purely environmentalist approach to problems of temperament and behavior is incomplete. Hence we may

<sup>2</sup> This is a very recent as well as constructive attitude toward obesity. Cf. the work of Bruch and Richardson and summaries of Evans ('47) and Gastineau and Rynearson ('47).

expect the potential and actual obese to show constitutional distinctions in physique and personality as well as distinctive social histories.

#### SAMPLE

The present study is limited to the first 103 adult white female obese outpatients studied at the Endocrine Clinic of Jefferson Hospital between May, 1944 and February, 1948. The sample is drawn overwhelmingly from a Pennsylvania and New Jersey urban environment, averages just under 40 years old, and is almost 60% overweight. As seen in table 1 it is not below average in occupational or, presumably, in income level in comparison with data of Folsom ('43 p. 593).

TABLE 1

*Occupations of Philadelphia obese white females and of husbands living with them*

OCCUPATION	OBESE WOMEN		HUSBANDS	
	N	%	N	%
Unemployed	6	5.8	5	7.3
Laborer or factory worker	4	3.9	16	23.2
Skilled laborer or mechanic	2	1.9	22	31.9
Tradesman	..	..	13	18.8
Salesman	2	1.9	5	7.2
Professional or secretarial	9	8.8	8	11.6
Housekeeper	11	10.7	..	..
Housewife	69	67.0	..	..
Totals	103	100.0	69	100.0

But the sample is not random. It excludes diabetics, hypothyroids, and others in whom obesity is secondary to a major organic disease. And its members are selected by coming to a hospital for treatment either of the obesity or of some related affliction. This implies that they had a strong enough incentive to seek help, whether the incentive was a realistic one or an excessively developed feeling of dependency. As Gray and Bayer ('35) noted in their samples there is a noteworthy tendency for the obese to drop treatment as soon as they find out that the cure for obesity is not magical. This



has reduced the size of sample for some of the social as opposed to medical and anthropometric data.

#### SOCIAL BACKGROUND

In the following discussion I shall rely as much on the psychiatric and social worksheets of Dr. R. A. Matthews, Dr. R. Schopbach and Dr. A. Kaplan (Psychiatry), and of Miss E. Jensen and Miss M. McCormick (Department of Social Service) as on my own data which cover marital, family, occupational, ethnic, and hereditary statistics.

Patients stated that their obesity began in childhood in 33 instances, during adolescence in 8, just after marriage in 12, following pregnancy in 34, after menopause or surgical operation in 6, and after adult psychic trauma in 8 of 101 cases.<sup>3</sup> The relation to crises of life seems significant.

Out of 98 women 67 were born and brought up in American cities (48 in Philadelphia), 13 in small towns, only 4 in rural communities, and 14 in foreign countries (mostly small town or rural and then urban U. S. A.) All studies stress the city environment's hostility to successful child-rearing.<sup>4</sup> And according to their subjective descriptions only 22.2% of 81 women had even an "average" childhood from the standpoints of family finances, friction, or disintegration. Thus 6.2% were "overprotected" in childhood, 14.8% suffered from excessive parental strictness, 16.0% were deprived through poverty or economic stringency, and 4.9% from both strictness and economic difficulties. Loss of one or both parents affected the childhoods of 22.2%, and financial difficulties accompanied family breakup in a further 13.6%. Thus three quarters of the obese sample had distinctly difficult and un-

<sup>3</sup> Corresponding percentages for Gurney's ('36) Buffalo series ( $N = 50$ ) are 16%, 8%, 9, 58%, 18%, 9, with 13 additional patients who found "no association" with onset of obesity. Some of these may already have been fat in childhood.

<sup>4</sup> Segoe ('37), esp. pp. 7-16. Kluckhohn ('41) stresses the further clash between "rugged individualism" in our prestige economy and the need for better planning. This has a critical effect on economically, socially or emotionally "marginal" people.

rewarding childhoods with death or separation of at least one parent in 35% of the sample, almost double the average according to data listed by Folsom ('43, pp. 333, 505).

The obese have on the average 2.12 brothers and 1.83 sisters, making a total of 4.95 siblings (including the patient). This indicates households ("census families") of almost 7 people, definitely larger than the average given by Folsom ('43, p. 134) for the general population. The total of 216 brothers to 289 sisters in 102 sibling groups of the obese gives a sex ratio of 74.4. Even if we subtract the 41 girls in 20 sibships lacking brothers in order to overcompensate for the selection of the sample by sex, the sex ratio is still 87.1 (see footnote 13, below). It is not clear whether this relative lack of brothers played a determining part in the sibling rivalry often mentioned by obese patients. And birth order also shows no significant trend.

Education is about average in duration (Capt and Hansen, 16th U. S. Census, '42, p. 131, urban columns), with a mean of 8.8 years of school completed for 85 subjects (omitting three who at least began college and 4 who had virtually no formal education). Yet few subjects seemed intellectually alert.<sup>5</sup>

Less than half of 58 subjects questioned have any tradition of eating rich food or large amounts of food as a family habit.

Menarche at 13.35 years indicates maturation if anything a little ahead of normal for the environment, especially for the group fat from childhood onward, with menarche at 13. This agrees with Bruch's findings ('39b).

With the exception of two who did not leave their parents until the ages of 30 and 46 and 4 who were still dependent on their parents, the subjects ( $N=87$ ) began their adult working lives at a mean of 16.5 years. In comparison with data of Gillette and Reinhardt ('42, pp. 611-612) and Fol-

<sup>5</sup> A mean I.Q. of 95 on 6 subjects with available data means little. The repeated impression of "slowness" was emphasized by contrast with the few who were quick to respond. There is nothing to show if this is acquired or constitutional.

som ('43, p. 183) this is not especially young for the subjects' general social background. There is a sharp biographic and personality contrast between those subjects who were forced to take an adult role at the ages of 13 or 16 (modal values) and those who remained dependent as long as possible.

Marriage at 23 years is the average for those who married, with modes at 17 and 20. This fits the urban middle class norm according to data of Notestein, quoted by Folsom ('43, p. 482), although a number of patients jumped into marriage as an escape from their family frictions and frustrations. Since only 11 subjects remained single (8 of these were overweight from childhood onward) the 89% married at some time comes close to the norm given by Folsom ('43, p. 477). But the 8 widows, 12 separated and divorced women, and three previously separated women suggest that the tendency for the marriage to break up is even stronger than normal in the obese series in comparison with data of Folsom ('43, pp. 411, 477, 505). Subjectively also the marital and family adjustment of the sample is far from satisfying: out of 68 subjects 24 describe very poor or poor adjustment, 18 fair, and 22 average; only 4 call their relations with their husbands "good." Likewise out of 47 subjects 24 have definitely frustrating psychosexual relations (with some stated infidelity of husbands), 8 have fair relations, 13 "average" and only two really satisfactory sex experiences.

In over half the series the patients' acceptance of responsibilities figures in complaints: 19 out of 60 subjects bear their responsibilities poorly, 36 fairly well, and 25 "average" or better. On the evidence of patients' biographies responsibilities actually borne by these women appear on the average more trying than usual, compared to the descriptions given by Furnas ('41) for families of similar income range. At least 20 out of 80 subjects have heavy duties, 32 increased responsibilities, 22 average, and 6 light responsibilities, or none at all. There is no association between actual living tasks and attitude toward them, except that those with light responsibility show the poorest attitude.

Though barely adequate for replacement of their parents (Thompson, '42, p. 439) and small compared to their own childhood families, the mean of 2.39 children for each married obese woman (out of 2.94 pregnancies) indicates a family of modern size or better (3.8 persons; see Capt and Hansen, '42, p. 45). In general the subjects live in houses rather than apartments, yet tend to withdraw from many community or neighborly activities and hobbies, often giving their obesity as excuse.

The number of children and material (as opposed to personal) difficulties, do not seem excessive for city life. Yet out of 89 subjects only 9% fail to complain of "nervous tension," with 29.2% reporting slight nervousness, 43.8% an intermediate degree, and 18% marked "tension." Three in this latter category are considered psychotic, and the remaining 13 have histories of "nervous breakdowns," depressions, amnesia, epilepsy, or anxiety syndromes. In many individual cases this anxiety and tension appears to connect in one direction with childhood or marital frustrations in human interaction, and in another direction with abnormally frequent or compulsive appetite often for starchy or "filling" food.<sup>6</sup> In some cases little breakfast is eaten, with almost an anorexia during part of the day, succeeded by a voraciously eaten supper or by continual nibbling which some patients themselves compare to the tippling of an alcoholic. Since oral satisfactions obviously substitute for other pleasures in the obese sample, it is tempting to consider this dominance of food a return to an "oral" stage of emotional development as implied by discussions in Fenichel ('45, pp. 62, 240, 381), or in some cases an arrest of emotional growth at a pre-adolescent level. Thus out of 61 subjects 45.9% show an abnormally strong attachment to one or both parents (more often the mother), in many cases actually feeling dependent on

<sup>6</sup> Cf. Bruch ('40a, '41), Rennie ('40), Gray ('43), Richardson ('46). There is a tendency toward rapid eating. According to Brobeck, Tepperman, and Long ('43) bolting food increased speed of weight gain in both normal and operated rats. This may parallel the "specific dynamic action of foodstuffs" of the clinician (cf. Bruch, '40b, Evans, '47, and Rony, '40).



parental support for calmness and disliking the parent giving the support. In this situation death of parents or parental attempts to shake loose the obese daughter can give rise to much family tension.

Another area of human relations which may be a source of tension is religion. Out of 89 subjects 57.3% are Catholics, 31.5% Protestants, and 11.2% Jewish. This contrasts in a direction probably typical for middle class Philadelphia with

TABLE 2

*Ethnic origins of Philadelphia obese white females compared with birthplace frequencies of the parental generation in Philadelphia based on figures in the abstract of the 15th U. S. Census (Steuart, '33)*

REGION	ANCESTORS	GRAND-PARENTS	PARENTS	SUBJECTS	PHILADELPHIA PARENTS
U. S.A.	4.3 <sup>1</sup>	32.5	49.5	86.4	47.3
Ireland	11.4	7.8	1.5		6.1
Great Britain	17.4	5.1	1.5		8.9
Baltic area	1.0	.5	.5		1.3
France	1.9	1.2			.5
Germany	18.6	7.5	2.4	1.0	7.1
Poland	4.8	5.3	4.8		4.2
Central Europe	5.8	5.8	4.8	1.0	2.8
Russia	4.0	4.1	3.9	2.9	9.4
Balkans	3.9	3.9	4.8	1.0	1.1
Italy	25.2	24.8	23.3	7.8	9.7
Other	1.6	1.0	2.0		1.4

<sup>1</sup>i.e. Old American with exact European sources unknown.

corresponding values of 28%, 69% (including non-communicants), and 3% for North America as derived from data in Irvine ('45, p. 367).

#### ETHNIC BACKGROUND

The question of geographic origin has both social and hereditary implications. Forty-two and seven-tenths per cent of the obese have American-born parents, more than half of these being "Old American." Eight and seven-tenths per cent are American-born of mixed parents, 35% American-born of foreign parents, and 13.6% foreign-born. Corresponding fig-



ures given by Steuart ('33, p. 100) from the 1930 census for Philadelphia whites are 42.9%, 9.0%, 26.9%, and 21.3%. Hence the obese show if anything a slight excess, even over the rather high Philadelphia figures, of second generation Americans. This is an urban population segment peculiarly likely to suffer from insecurity and maladjustment (Smith, '39, pp. 243-376).

The 15 foreign-born women are mainly from Italy and South Russia. And the foreign-born parents come almost entirely from East-Central Europe and Italy, fitting the average pattern of most recent immigration from Europe. In accordance with its peculiar frequencies of religions the sample shows more dominance of Italian, German, and Irish "ancestries" over British origins than one would expect in an average American group. But the comparative data of table 2 and the historical summaries of Adamic ('45, pp. 19-36, 167-195, 304-350) show the sample fairly representative of Philadelphia as a whole (except perhaps for excess of Italian and paucity of Russian ancestries).

#### MORPHOLOGY

The sample's ancestries stress the parts of Europe where Alpine (and other more rugged) "survivors" of Upper Palaeolithic European populations are relatively numerous according to Coon ('39, map 9, and pp. 291-293). Thus the type distribution in table 3, following Coon's terminology, classifies over half of the series as showing phenotypic trait combinations which are thought to have been evolved in Europe during the last glacial period. Less than one-fifth of the series approximates the long-headed types characteristic of various peoples who penetrated Europe from southeast to northwest during the great population expansion of the third millennium B. C. and who revolutionized the ecology of the area by bringing first farming and later urban civilization from the Near East.<sup>7</sup> These latter physical tendencies, con-

<sup>7</sup> Coon ('39, pp. 55, 78-173, 292) adapting human biological data to prehistory as synthesized by V. G. Childe and others.

spicuous by their weak effect in the obese sample, are dominant in the Old American blend as at present defined. Hence the excess of Palaeolithic survivor tendencies in the obese sample has significance. The people inhabiting Europe during the last glaciation must have developed a relatively great body mass compared to surface as an adaptation to a cold climate according to Bergmann's and Allen's rules as summarized by Rensch ('36, pp. 347-359). The experiments of MacArthur and Chiasson ('45) on heavy and light races of mice show

TABLE 3

*Body build and morphological type frequencies of Philadelphia adult obese white females*

SOMATOTYPES	FOUND	EXPECTED	MORPHOLOGICAL TYPES	
	%	%		%
711	6.80	.2	"Upper Palaeolithic:"	
622, 522, 533, 433	8.74	5.7	Brünn	14.5
721, 731, 621	20.39	.6	Borreby	7.8
631, 641	25.24	.7	Alpine	30.1
632, 532	15.53	2.4		
541	6.80	.3	"Intermediate:"	
542, 543	6.80	2.2	Mixed Alpine	21.3
551	.97	.1	Dinaroid	7.8
712, 612, 613, 623, 523	3.88	1.4		
514, 524, 534, 515, 424	...		"Mediterranean:"	
442, 443	3.88	8.5	Basic White	7.8
453	.97	1.0	Mediterranean	2.9
			Nordic-Iranian	7.8

that the genetic determination of such body massiveness depends primarily on rapid total growth from which follows heterogonic shift in limb and organ proportions. Hence it is not impossible to regard obesity as one part of a body build complex evolved in Europe during the last glacial period (cf. Angel, '48). Upper Palaeolithic figurines and the body build of modern sub-arctic peoples also fit such an hypothesis.

This speculation suits the somatotype distribution of the sample, shown in table 3, which is concentrated in less than one quarter of the entire somatotype range as determined so far by Sheldon and his co-workers ('40) on college males.

Almost all women in the obese series are morphologically dominated by the first or endomorphic component, though the whole reliability of judging the obese body build depends on the subjective accuracy of the allowance made for excess fat. This is only somewhat less uncertain than Lasker ('47) has shown to be the attempt to type nutritionally abnormal subjects when one is ignorant of the changed nutrition. Thus the average obese somatotype of 5.83—2.88—1.50 may very probably overestimate the degree of dominance of the first component. Nevertheless the obese are far more endomorphic than the average Radcliffe college female given by Bullen and Hardy ('46) as 3.08—3.40—3.42, and well exemplify the following features described by Sheldon ('40, pp. 37—39) as typical of endomorphy: round, soft, central concentration of mass, with low stature-weight ratio, lack of obvious muscularity, tapering and small-boned limbs, smooth skin, and fine hair on round head. The second, mesomorphic, or "locomotive" component is extremely hard to judge under the fat blanket. As indicated by the illustrations the obese subjects slump physically and are over-relaxed in appearance, but have muscularity apparently not far below normal. The slender wiriness and delicacy of Sheldon's third component (ectomorphy) is conspicuously weak except for its appearance with an impression of imbalance in the median face, neck, waist, or distal extremity regions of a few individuals. No attempt has been made to measure dysplasia, which is striking in a few individual obese.

But variation in the fat distribution pattern can be conveniently analysed according to Skerlj's ('39) classification. Comparison with his data for an Austro-Yugoslav series shows the obese to have an excess of all the variant or exaggerated fat patterns except the "extremities" type and a deficiency of the "normal" female fat pattern.<sup>8</sup> There is a

<sup>8</sup> Pattern:	Normal %	Rubens	Trochan- teric	Lower	Upper	Extrem- ities	Juvenile %
Yugoslavs:	61.9	9.9	5.7	6.8	3.1	5.7	3.6
Obese U.S.A.:	13.6	12.6	10.7	17.5	15.5	3.9	26.2

particular excess of the "juvenile" fat pattern which includes over one quarter of the obese. As suggested in an index of gynandromorphy just below three on a 7 point scale of intensity many of the obese show a perceptible lack of feminine body traits,<sup>9</sup> though this slight variation is as much in an infantile as in a male direction.

TABLE 4

*Selected measurements of Philadelphia obese compared with adult white females from the whole U.S.A. (O'Brien and Shelton, '41)*

CHARACTER	ADULT OBESE PHILADELPHIA	U.S. WHITE FEMALES		ADOLESCENT OBESE
		Total	220-229 lbs.	
N	103	10,042		20
Age	39.2	44.4	48.3	15.4
Weight in lb.	223.2	133.5	224.6	201.5
Stature in cm	158.2	160.4	163.1	161.6
Sitting height	85.7	84.9		86.2
Chest circumference	107.2	88.3	110.8	101.7
Waist circumference	104.0	74.0	108.7	91.2
Hip circumference	122.0	98.6	123.3	114.9
Thigh length	43.2	43.3		41.5
Shin length	35.2	36.7		36.7
Malleolar height foot	6.7	7.1		6.8
Stature/ $\sqrt[3]{\text{weight}}$	10.3	12.4	10.6	10.9
Relative sitting height	54.2	52.9		53.3
Crural index	81.7	84.6		88.3

## MEASUREMENTS

Table 4 shows that, in addition to their excessive weight and body girths, the obese sample is definitely shorter than the general female white American population described by O'Brien and Shelton ('41) in their study for clothing size standards. This is not a simple result of mechanical pressure of excess weight since the 220-229 pound segment of the general population is even taller than the general average. Like-

<sup>9</sup> Sheldon ('40, pp. 72-75) outlines mainly female traits appearing in male physiques. Hence there is no real standard for women. But see both Bayer ('39) and Bullen and Hardy ('46) for other possibilities and difficulties of defining sex criteria and overlap in detail.



wise the high relative sitting height and rather low crural index of the obese indicates most of the shortening to be in the shin segment of the lower extremity (in so far as derived thigh and direct shin measurements on the obese are accurate). The slight lowering of foot height by less than one half centimeter is the only evident mechanical effect of weight on stature, though there must also occur some intervertebral disk compression (perhaps balanced by increased ischial fat in sitting height). The medial malleolus is lowered in spite of the padding of fat on the obese sole and shows incipient collapse of the longitudinal arch of the foot.

Presented in table 5 (first column), measurements on the obese sample followed the definitions of Martin ('28) and were taken with as much pressure as possible over bony landmarks. Only iliocristale and especially tibiale are notably hard to locate in the obese. Table 5 compares the obese with Bayer and Gray's ('34, '36) series of healthy working women of comparable economic status in San Francisco, and with Draper's ('24) gall-bladder disease females from the New York area. In selecting their working women sample Bayer and Gray rejected 4 out of 5 volunteers as having been in poor health and noted that among those rejected for overweight some other disease was always present also. These working women differ further from the obese sample in including fewer housewives, in being more native American, and of course more selected by westward migration. This is the best available control sample. Steggerda, Crane and Steele's ('29) Smith College series (like a number of other college series) is sharply selected economically, is young, and though heterogeneous in ethnic origins shows much more English ancestry than the obese sample. The linearity, tallness, and lightness of this series, furthermore, is partly a result of class selection. O'Brien and Shelton ('41) find a stature increase of over 2 cm between the \$1,000.00 and \$3,000.00 income groups on the one hand and on the other



TABLE 5

*Measurements and indices of Philadelphia obese females compared with healthy working women from San Francisco (Bayer and Gray, '34), gall-bladder patients from New York (Draper, '24), and Smith College students (Steggerda, Crane and Steele, '29)*

CHARACTER	PHILADELPHIA OBESE			WORKING WOMEN, SAN FRANCISCO	GALL- BLADDER PATIENTS	SMITH COLLEGE STUDENTS
	Basic data	Corrected for excess fat				
	M	M	p.e.			
N	103	103		100	33	100
Weight in pounds	223.19	120.04	2.41	135.4	159.8	122.35
Stature in cm	158.16	158.16	.43	161.54	155.62	162.81
Span	161.03	160.65	.48		156.87	164.02
Sitting height	85.73	84.60	.24	85.50	83.46	86.84
Bi-acromial breadth	36.89	34.09	.11	35.54	34.49	35.61
Bi-iliac breadth	32.33	27.74	.13	30.11	29.33	27.23
Bi-trochanteric breadth	36.45	31.86	.14			31.86
Chest breadth	29.47	26.67	.13	27.57	26.71	25.07
Chest depth (a.-p.)	23.51	21.28	.15	20.59	21.60	18.85
Abdomen depth	28.14	22.32	.24			
Neck circumference	39.08	32.05	.17		34.28	30.46
Chest circumference	107.21	87.91	.53	85.89	88.38	79.39
Waist circumference	104.02	85.30	.75	73.22		
Hip circumference	121.99	100.03	.79	99.77		
Brachial length	29.92	29.92	.12		27.24	29.16
Forearm length	23.22	23.22	.87		21.78	22.27
Hand length	16.92	16.76	.06	17.78	16.93	18.74
Hand breadth	7.78	7.47	.03	8.11	8.02	7.98
Malleolar height foot	6.69	6.69	.06		6.66	7.76
Foot length	23.96	23.59	.08			23.67
Foot breadth	9.38	9.00	.04			8.32
Stature/ $\sqrt{\text{weight}}$	10.26	12.62		12.40	11.30	12.80
Relative sitting height	54.16	53.49	.10	52.99	53.6	53.28
Relative shoulder br.	23.32	21.55		22.02	22.1	21.9
Relative hip breadth	20.44	17.54		18.65	18.8	16.8
Relative chest circumf.	67.79	55.58		53.15	56.8	48.69
Relative hand length	10.70	10.60		11.00	10.88	11.51
Shoulder-hip br. index	87.76	81.38	.39	84.86	85.0	79.49
Thoracic index	79.83	79.83	.37	74.60	80.9	75.2
Brachial index	77.61	77.61			79.9	76.32
Hand, length-br. index	46.01	44.58		45.88	47.4	42.47
Foot, length-br. index	39.14	38.18				34.81

TABLE 5 (continued)

CHARACTER	PHILADELPHIA OBESE			WORKING WOMEN, SAN FRANCISCO	GALL- BLADDER PATIENTS	SMITH COLLEGE STUDENTS
	Basic data	Corrected for excess fat				
	<i>M</i>	<i>M</i>	<i>p.e.</i>			
Head circumference (mm)	562.08	555.80	1.00		541.2	550.15
Head length	186.07	184.07	.46	<i>187.76</i>	182.3	186.43
Head breadth	150.01	148.01	.32	148.78	148.8	145.98
Auricular height	117.28	116.28	.37	<i>120.06</i>		124.45
Minimum frontal br.	107.08	105.08	.28			102.72
Bizygomatic breadth	138.33	135.33	.30	<i>133.00</i>	<i>132.6</i>	130.46
Bigonial breadth	104.84	101.84	.34		99.6	100.37
Total face height	114.25	112.75	.47	114.10	<i>110.2</i>	111.99
Upper face height	68.62	68.62	.29		65.0	
Nose height	50.91	50.91	.25	<i>52.20</i>	50.9	53.61
Nose breadth	33.69	33.69	.20	33.51	34.3	32.18
Interorbital breadth	31.66	31.66	.18		30.2	
Chin height	39.07	37.57	.21		<i>34.7</i>	
Cephalic index	80.66	80.41	.25	79.24	81.5	78.50
Length-height index	63.03	63.17		64.0		66.59
Breadth-height index	78.18	78.56		80.7		84.89
Fronto-parietal index	71.38	71.00				70.3
Cephalo-facial br. index	92.24	91.43	.18	<i>89.47</i>	89.1	89.4
Zygo-frontal index	77.41	77.65				78.7
Fronto-gonial index	97.91	96.92				97.8
Zygo-gonial index	75.79	75.25			75.2	77.0
Facial index	83.00	83.72	.40	<i>85.89</i>	83.2	86.95
Upper facial index	49.61	50.71			49.0	
Nasal index	66.83	66.83	.47	<i>64.63</i>	67.4	59.89
Mean somatotype	5.8-2.9-1.5				5-3.5-2	
Mean V 17 measurements	6.25			5.46		5.71
Mean $\sigma$ of 5 indices	4.70			4.70		3.81
Age	39.18	39.18	.63	<i>36.2</i>	41.4	20.2
Age at menarche	13.35	13.35		13.6		

Note: values which differ significantly ( $> 3 \times p.e.$ ) from the "corrected" obese means are italicized, except in the case of indices calculated directly from means of measurements where no probable error is available. Obese subjects were measured in hospital gowns, in the morning only (9-12 A.M.). Foot measurements were taken with subjects sitting. Divergences in technique affect comparisons in hand and foot measurements, auricular height, and measurements depending on locating nasion.

find that the general Pennsylvania-New Jersey area female population is shorter than the U.S.A. average by 2 cm, heavier by almost 5 pounds, and larger in hip girth by 2 cm.<sup>10</sup>

In order to make any real comparisons with the obese it is necessary to work out corrections for each measurement to allow for the effect of fat, and thus to reach their (sometimes theoretical) unaffected state. These are no more than approximate corrections because of the difficulty of locating the plane of measurement on X-ray photographs and because of the small number of subjects available. Through cooperation of Dr. P. Swenson and the Curtis Clinic X-ray department, 4 obese and 4 normal women were photographed supine at 4 feet target distance with anthropometer in place for bi-iliac and chest breadth measurements, giving correction factors of 14.2% and 9.5% of the respective measurements. For other measurements similar corrections have been made in table 5. In the two control measurements compressed tissue was 43% of uncompressed tissue compared to only 20% in the control group where the uncompressed tissue thickness was just over a quarter that in the obese.<sup>11</sup>

Circumferences were reduced by 18% since pressure was not used in taking these though the tape was pulled "tight." Weight was also corrected by 18% of its cube root. This corrects to what would be starvation conditions for endomorphs. Sitting height was reduced by 3.5% of bi-iliac. For head and upper face measurements a 1 mm correction was made for tissue thickness increase, and for lower face 1.5 mm by extra-

<sup>10</sup> O'Brien and Shelton ('41) also point out that married mothers are shorter and stockier than single women. Foreign-born women are also shorter and relatively stockier than native-born. Taken in connection with the tallness and relative slimness of upper classes (cf. Sheldon, '40 *passim* and Bullen and Hardy, '46 plate 3 for illustrations of this) and the increasing size of upper and middle class Americans in the last few generations this suggests selection and environmental factors as the predominating causes. Hence it is noteworthy that none of the obese complain of inadequate childhood diet.

<sup>11</sup> Uncompressed tissue thickness for hips and chest is 53.6 and 44.6 mm in the obese and 17.2 and 10.4 mm in the controls respectively. Compressed tissue thickness for hips and chest is 26.5 and 16.7 mm in the obese and 2.6 and 3.5 in the controls respectively.

pulation beyond the thorax correction. The obese were all measured in the morning, clothed in hospital gowns.

The metric distinctions of the "corrected" obese sample seen in table 5 are short stature (and light weight), rather small-boned frame as indicated by narrow shoulders and hips,<sup>12</sup> long and notably deep trunk contrasted with rather short extremities, relatively short shins and upper arms, small and relatively short hands, and wide and low (collapsed and spread) feet. The head is short, the face relatively wide, and the nose short, rather wide, and frequently snub or blobby, fitting a slightly "baby-faced" impression which otherwise may be largely a result of the fat covering.

By "civilized" standards teeth are fairly good, with an average of almost 13 healthy teeth remaining in the mouth. One-fifth show partial or complete suppression of third molars, and an appreciable minority have edge bite. Almost two-thirds have some degree of development of eyefolds, more often median and external than internal. Iris color is dominantly light-mixed with a greenish tendency predominant and over half the irides showing some yellow pigment. The iris pattern, dominantly rayed, is irregularly scalloped in one-fifth of cases. Hair is fine-medium in texture, straight to low wavy in form, and dark in color with some degree of red pigment perceptible in over half the series.

The variability of the obese is fairly high, as seen in table 5. The mean  $V$  of 17 measurements is 6.25, as compared with 5.46 for the healthy working women and 5.71 for the Smith College series. The mean  $c$  for 5 indices is 4.70 compared with 4.70 for the healthy working women and 3.81 for the Smith College series. Hand breadth, face height, and relative sitting height all show relatively low variability, whereas abdominal

<sup>12</sup> Also by inspection and palpation and by X-ray photographs taken on a few patients. A few roentgenograms taken by Dr. H. Reinhardt under Dr. P. Swenson's direction suggest large viscera, with the greater curvature of the stomach well above the 4th lumbar vertebra in the erect position. "Lipping" of the vertebral bodies also occurs, indicating hypertrophic arthritis and fitting an impression of increased lumbar curvature and the frequent complaints of low back pain.

depth, circumference measurements, foot height and the nose all show high variability. Obviously variation in the deposition pattern and amount of fat is the major factor in raising the metric variability of the obese. But there also exists a more heavy-boned and rugged minority in the series (individuals who rate 4 or higher in Sheldon's second component) which contrasts with the rather slender-boned majority.

On the whole the obese differ from the healthy working women about as much in their direction as the Smith College series does in its own direction. On the other hand, with the exception of slightly smaller body and face, Draper's gall-bladder patients approximate the obese quite closely if one makes allowance for the different fat padding of each group.

The most sweeping summary of these data emphasizes the retention by the obese of slightly juvenile proportions and morphological traits. And though this certainly does not hold true for all individuals in the series, the extreme endomorphs do tend to have relatively higher sitting heights and more juvenile proportions than those in the obese sample nearer the middle of the somatotype range. The discussions of Bruch ('39a), relying partly on Richey's data, and of Bayley ('46) stress that early-maturing children tend to be taller and bigger as a whole than their peers before puberty but cease growth also ahead of the others. Other things being equal these early-maturers should tend in adulthood to be shorter and stockier and to retain juvenile body proportions through heterogony since, as compared with average, a relatively greater part of their growth took place in childhood. Reynolds ('46) points out that early-maturers have a higher ratio of fat to bone than usual as seen in leg X-rays. And Bruch ('39a) points out that the skeletal maturation and puberty of obese children tend to be advanced, in consonance with their excessive total growth as children. The present sample only partly confirms this hypothesis. Since the bony growth pattern and timing of cessation of growth is dominantly determined by heredity, as indicated by work of Reynolds ('43), one might expect correlation in the obese sample between type of paren-



TABLE 6

*Morphological observation percentages of Philadelphia obese females*

<i>Abdominal fat</i>		<i>Hair color (excluding 10 gray and white)</i>	
Average	0	Dark brown	33.33
Bulge	27.18	Brown	34.41
Creased sag	31.07	Red-brown	3.28
Apron	41.75	Golden-brown	11.83
<i>Nose form (profile and tip)</i>		Ash-brown	12.90
Concave with snub tip	18.63	Red	1.08
Concave and blobby tip	8.82	Golden	2.15
Wavy { and snub tip	20.59	Ash	1.08
or { and blobby	4.90		
straight { and rounded	12.75	<i>Red pigment present</i>	55.56
profile { and angled	17.65		
Long and straight	9.80	<i>Hair form</i>	
Convex	6.86	Straight	51.46
<i>Eyefolds, degree</i>		Low waves	36.89
None	36.00	Deep waves	10.68
Slight	44.00	Curly	.97
Medium	15.00	<i>Hair texture</i>	
Marked	5.00	Coarse	11.76
<i>Eyefolds, type</i>		Medium	46.08
Internal (20.3)	13.00	Fine	42.16
Median and int. (3.1)	2.00	<i>Tooth eruption</i>	
Median (31.3)	20.00	Incomplete	4.85
Median and ext. (23.4)	15.00	Total M <sub>3</sub> suppression	9.71
External (20.3)	13.00	Partial M <sub>3</sub> suppression	9.71
Complete (1.6)	1.00	Complete	75.73
<i>Iris color</i>		Average no. unerupted teeth	.7
Dark brown	5.88	<i>Teeth lost</i>	
Light brown	4.90	None	2.91
Dark-light brown	6.86	1-6	23.30
Green-brown	27.45	7-12	33.98
Gray-brown	10.78	13-18	19.42
Blue-brown	15.69	19-24	6.80
Green	10.78	25-30	5.83
Gray	1.96	31-32	7.77
Blue	16.67	Average no. of lost teeth	12.51
<i>Iris, yellow pigment</i>		<i>Teeth carious (excluding 9 edentulous)</i>	
None	38.83	None	9.68
Slight	36.89	1-3	24.73
Medium and pronounced	24.27	4-6	23.66
<i>Iris, mixed eye pigment balance</i>		7-9	21.51
Very dark	6.45	10-12	12.90
Medium dark	24.59	13-15	5.38
Even	16.39	16-18	1.08
Medium light	19.67	25-27	1.08
Very light	34.43	Average no. carious teeth	5.94
<i>Iris pattern</i>		<i>Type of bite (N = 76)</i>	
Clear	0	Under	3.95
Rayed	62.14	Edge	13.16
Zoned	7.77	Slight overbite	26.32
Scalloped	21.36	Medium overbite	43.42
Diffuse	5.83	Pronounced overbite	13.16
Spotted	2.91		

tal mating, menarche, relative sitting height (as an oversimplified index of juvenile or adult body proportions), abdominal fat mass (as an index of degree of obesity), and fat pattern. But these factors are not associated with each other. Furthermore the obese menarche at 13.35 years is not significantly earlier than that of the healthy working women. And the menarche of 30 obese women who have been fat from childhood onward is 13.03 years.<sup>13</sup>

#### HEREDITY

Nevertheless it is hard to view any connection between the slightly juvenile body build and morphology of the obese sample, their psychosomatic mechanism for weight gain, and their somatotype balance (with its implied linkage to "temperament"), except as part of a complex shaped by heredity though set in motion and limited by environmental factors which are largely social.

Danforth ('27) has described in mice a semi-lethal recessive gene, AY, which produces both a yellow coat color (epistatic to most other self colors) and obesity through over-eating. Homozygotes die. And yellow mice show a short life and reproductive cycle and relatively increased body length (i.e. infantile proportions) according to Benedict and Lee, and Castle, quoted by Dickie and Woolley ('46). In man the data of Liebendoerfer ('23), Gurney ('36), and Rony ('40) show that obesity is inherited and that it is not controlled by a single recessive gene.

About one-fifth of the Jefferson obese sample (including adolescents) have average parents, and one quarter fat parents, the remainder of matings being between fat and average, according to the patients' descriptions, which it was not possible to check. As seen in table 7 these proportions agree closely with Gurney's findings. And about half of the parents and a large proportion of other relatives are said to be obese.

<sup>13</sup> Menarche, age, etc., are of course calculated from the middle of each year, since our society conventionally counts age from the preceding birthday and not to the nearest birthday.

Gurney ('36) shows that out of 176 children from matings of average parents 9% were fat. This serves as a control on the rarity of genetic determinants for obesity which might be recessive, if one allows further for psychosomatic effects of environment. In the present sample as seen in table 7 almost 40% of the offspring of average parents were fat, when these families are selected by having at least one fat

TABLE 7

*Genetic background in obesity, based on descriptions by 98 adult and 18 adolescent Philadelphia obese white females<sup>1</sup>*

TYPE OF MATING	PARENTAL COMBINATIONS		OFFSPRING		(INCLUDING SUBJECTS)		
	N	%	♂	Fat ♀	♂	Thin ♀	Total
Fat ♂ × fat ♀	30	25.86	32	51	25	22	130
Average ♂ × fat ♀	42	36.21	33	69	54	54	210
Fat ♂ × average ♀	18	15.52	13	27	19	11	70
Average ♂ × average ♀	26	22.21	8	40	43	37	128
Average ♂ × average ♀ (Gurney, '36)			16		160		176

TYPE OF MATING	% SONS FAT	% DAUGHTERS FAT	% CHILDREN FAT	SEX RATIO	FAMILY SIZE
Fat ♂ × fat ♀	56.1	69.9	63.9	78.1	4.33
Average ♂ × fat ♀	37.9	56.1	48.6	70.7	5.00
Fat ♂ × average ♀	40.6	71.0	57.1	84.2	3.89
Average ♂ × average ♀	15.7	52.0	37.5	66.2	4.92
Average ♂ × average ♀ (Gurney, '36)			9.0		

<sup>1</sup> See also footnote 13 p. 453, for factors affecting the sex ratio.

daughter. Half the offspring of *fat* × *average* parents were fat and almost two-thirds of the offspring of *fat* × *fat* matings were fat. Gurney ('36) found percentages of fat offspring for the last two types of mating at 41% and 73% respectively. The data do not fit any such simple hypothesis as two-gene dominant causation. But segregation obviously takes place, and a number of genes appear to be involved.

A further peculiarity seen in table 7 is the sex ratio in the obese sample's sibling groups as a whole and in the different

types of mating.<sup>14</sup> There are fewer males (and larger families) among the progeny of *average*  $\times$  *average* matings (those in which genes for obesity are frequent, at least) and *fat female*  $\times$  *average male* matings than among the offspring of *fat*  $\times$  *fat* and *average female*  $\times$  *fat male* unions. This is not inconsistent with an hypothesis that one of the genes which in some cases helps to determine obesity is a sex-linked recessive lethal gene. Spuhler ('48) points out that such sex-linked recessive lethals do very probably occur in man. Such a gene might be expected to be more frequent among the females of the *average*  $\times$  *average* matings with at least one obese daughter, where presumably the interacting non-recessive genes mainly responsible for obesity would be less frequent than in matings involving one or more fat parents (especially a fat

<sup>14</sup> The precise deviation in sex ratio in obese families is not obtainable from the present series of white adults and adolescents since the sample is selected by having at least one female sibling (the patient) and by important but scarcely tangible social factors. If, in the adult series only, we eliminate those 20 families which produced *only* female offspring the sex ratio of this reduced sample rises by 13%. But if a sex-linked recessive lethal or semi-lethal gene is more frequent than normal in potentially obese families we would expect more sibships of girls only than of boys only and a lower sex ratio as family size increased. The data for *average*  $\times$  *average* and *fat female*  $\times$  *average male* matings in table 7 suit this expectation. And 20 boyless sibships among the adult obese is a notably high proportion: this would indicate that one third (20 + 20 out of 102 + 20) of obese families averaging just under 5 children each were of one sex only. The probability that all offspring in a family of 5 would be of one sex is  $p^5 + q^5$  or  $1/16$  where  $p$  and  $q$  are the probabilities (each about  $1/2$ ) that a given child will be male or female. Hence there is a real and marked excess of boyless families among the obese, and to subtract 20 families of girls only grossly over-corrects the sex ratio *for selection by sex*. The true correction for effects of this selection by sex is of the order of 2-4% ( $1/32$ ). There are further considerations. The relatively urban derivation of the obese sample slightly lowers the sex ratio. And the frustrations, rivalries, and parental reactions in a family of girls only probably favors obesity. We can guess the strength of this sibling rivalry factor as producing at most very little more than the 13% shift in sex ratio attributable to the excess number of all-girl sibships, though the exact strength of female sibling rivalry as a cause of obesity will remain unknown until a thorough genetic study shall have measured the frequency of the hypothesized sex-linked recessive lethal factor. Yet even allowing a 15-25% total effect of unknown social, psychological, plus sampling selection the sex ratios in table 7 still fit a tentative hypothesis of increased frequency of some factor reducing the number of male children by at least 10% and probably much more.



father). On the other hand the relatively larger family size of the *average*  $\times$  *average* and *fat female*  $\times$  *average male* matings may have purely psychological or social biological and not genetic determinants. Likewise the relative excess of fat females over fat males among the parents and siblings of the obese (about 60% of females are fat as opposed to 40% of males) may express as strongly the effects of genetic sex limitation and social sex differences in activity as the effects of a hypothetical sex-linked recessive lethal factor which present data are inadequate to test. Here we are hampered by inability to record the potentially obese as well as the actually obese phenotypes.

In the case of taste-blindness also (using a 1:5000 solution of phenyl-thio-urea), where 30 out of 77 subjects are taste-blind, the data are insufficient so far to claim any connection with obesity as Terry and Segall ('47) have for diabetes, though the frequency is about the same. Out of 80 subjects 29 are unable to roll their tongues cylindrically. Blood-types are currently being studied on obese subjects together with further attempts to study their siblings and parents (through the generosity of the Viking Fund).

The problem of genetic determination of obesity is further complicated by the questions of the effect of environment, especially family eating habits and psychic traumata, and the interconnected question of why some obese women become fat only after pregnancy whereas others are fat all their lives. Bauer ('42, pp. 153-4) has argued that if obesity is non-hereditary all the siblings in a *fat*  $\times$  *fat* mating should be fat by imitation and family tradition. This is an exaggerated point of view since differences in education and frustrations between parents and children would interfere. But if heredity, with gene recombination, did not play a major part in producing the potentiality for obesity there should be many more fat offspring of fat parents and fewer fat offspring of thin parents. Furthermore those who remain fat from childhood up do differ in body type from those who become fat only after pregnancy. Thus 33 subjects fat in



childhood have an average somatotype of 6.0 — 2.9 — 1.4, slightly more endomorphic than the total group, and 34 subjects fat after pregnancy have somatotype averaging 5.5 — 3.1 — 1.6, slightly more mesomorphic than the total group. Similarly there is a weak association ( $\chi^2 = 22.08$ ,  $P < .05$ ) between type of mating and period of onset of obesity: those fat in childhood are rare in *average*  $\times$  *average* or *average female*  $\times$  *fat male* unions.

This might most plausibly have a social explanation, however. And table 8 shows that offspring of *fat*  $\times$  *fat* matings

TABLE 8

*Average somatotype related to type of mating and to the ability to lose 25 lb. of weight or more, in Philadelphia obese females*

	N	SOMATOTYPE COMPONENTS		
		First	Second	Third
Total series of obese females	103	5.83	2.88	1.50
Both parents fat	15	5.67	3.27	1.47
Both parents fat and weight loss ability	9	5.89	3.22	1.67
One parent fat and weight loss ability	17	5.59	3.24	1.59
Parents average and weight loss ability	5	5.60	2.80	1.80
Both parents average	19	6.05	2.42	1.53
One parent fat	36	5.97	2.75	1.33

are notably stronger in mesomorphy than offspring of *average*  $\times$  *average* parents producing fat children. This illustrates the complexity of obesity's relation to body build. As indicated earlier, it is probably that obesity had a highly useful place in Upper Palaeolithic European populations who were as a whole very robustly built. Possibly more of such robusticity is available genetically in *fat*  $\times$  *fat* matings than in those *average*  $\times$  *average* ones which produce fat children.

#### PHYSIOLOGY AND TEMPERAMENT

In study of the psychosomatic status of the obese the question of weight loss is paramount. In accord with previous findings the present sample has a basal metabolic rate of

+ 6.25, showing that the consumption of oxygen still bears a "normal" relation to the increased body surface in obesity. But Evans ('47) points out that heat production rises much less steeply after eating in the obese than in the non-obese, presumably helping to delay the sense of satiety. And Newburgh and Conn ('44) point out that the decreased total physical efficiency of the obese causes absolutely greater than normal production of heat and demands more food for satisfaction. Under these circumstances losing weight would appear to demand either a considerable increase in the already overloaded energy expenditure mechanism of the body or a psychological reduction of appetite (or both). In accord with this the 31 subjects who at some time in their lives have lost 25 pounds or more show a slight excess of mesomorphy. But this increased robusticity as seen in table 8 is so slight that the temperamental factors in weight control appear to be much more important than the purely physical ones (even though linked with them). Thus those genetic factors which condition growth rates and produce the slightly infantile body build noted in obesity in general, appear to have little to do with the ability to lose weight and the temperamentally conditioned behavior patterns involving appetite.

It is true that Sheldon and Stevens ('42) have shown correlations as high as .80 between somatotype components and parallel temperamental tendencies seen as dynamic aspects of the morphological components. With present data Sheldon cannot try to decide how far these correlations result from observer's bias, from heredity, from the social environment alone, or from conditioning by the psychosomatic and social repercussions of what Schilder ('35, pp. 77, 170, 201-249) calls the body image. Thus once she has become obese the whole social orientation of a woman is changed and limited by her physical appearance.

According to Sheldon's correlations the dominantly endomorphic obese sample should show relatively slow and relaxed movement and reaction, a certain restriction of energy spent often along social lines to achieve both physical comfort and

love from other people. The obese group should be complacently tolerant, "extraverted," and over-friendly (almost childish) in enjoying the approval of others and the pleasure of eating and digestion. So far as perceptible in the social data at the beginning of this paper, the pattern actually observed might well be thought of as an inversion of this prediction through the effects of frustration and deprivation of the social approval and love necessary for full expression of "viscero-tonia" as opposed to "somatonia." In fact the nervousness, worry, hesitancy to act aggressively, and apparent hidden tenseness noted in most of the subjects might express more "cerebrotonia" than fits the lack of delicacy in body build. Hence it is hard to make Sheldon's correlations of temperament with body build explain the obese personality except through hypotheses of environmental inversion and perhaps also temperamental "disharmony." Yet metrically the obese sample tends away from those disproportions which Seltzer ('46) finds correlated with lessened stability of personality.

The personalities of the obese seem simply to become fixed or partly fixed at too early a growth stage, in fact at the oral stage of development of the Freudian school. If this personality distinction is in any way genetically conditioned (through post-pubertal rapid slowing of growth, etc.) it would make childlike dependence on the approval of others, love of eating, and increased appetite more exposed than usual to exaggeration through social difficulties and training.

As stressed by other workers such as Bruch ('40a) and Gastineau and Rynearson ('47) the exaggerated appetite which leads to obesity almost certainly results from neurophysiological interaction between cerebral cortex, hypothalamus, and body, with the hypothalamus responding to and producing visceral emotion (in this case appetite). Ranson ('43, pp. 227-233) outlines the still inadequate knowledge of neural pathways between cortex, hypothalamus dominating visceral nervous function, and such visceral efferents as the vagus nerve. But he stresses the physiological reality of such con-

nections. And the animal experiments of Brobeck, Tepperman, and Long ('43), of Heinbecker, White and Rolf ('44), and of Hetherington ('43) show that the caudal part of the paraventricular nuclei, (lateral to the ventromedial nuclei) with the tracts descending from them are the areas of the hypothalamus whose injury produces exaggerated appetite.

From the other end Bruch ('40a) quotes from Cannon and others the well established observation that vigorous contractions of an empty stomach produce sensations of hunger (rather than appetite). And Wolf and Wolff ('42) and others have shown that in many people sensations of anxiety, hostility, and resentment (such as are frequent in the obese) produce turgidity of the gastric mucosa, acid secretion, and vigorous contractions of the stomach at times quite apart from the regular rhythm of the stomach. In some cases this continues until ulcers result. It is obvious that such a stepping up of gastric activity as a result of anxiety via the hypothalamus as mediator of visceral control could produce increased hunger pangs in the obese. Then through interaction between the cortex and hypothalamus, perhaps paralleling on a smaller scale the cortico-thalamic interaction analyzed by Papez ('44), the increased appetite of the obese may be synchronized with these hunger pangs and anxieties to produce a vicious circle of reaction. This of course is pure speculation.

Conceivably the particular inherited reaction pattern of the potentially obese person includes a weakened linkage of the paraventricular nuclei or an increased sensitivity of other hypothalamic nuclei such that unfavorable conditioning results in a different set of synaptic traces than those set up, for example, in a potential peptic ulcer patient. It is difficult except through some indirectly genetic factors to relate the diverse end results of this partly parallel neural mechanism with the contrasting basic body builds (largely hereditary) of obese and ulcer patients.

In summary it seems possible that the inheritance of a psycho-physiological sensitivity of the neural appetite mechanism is a primary factor in obesity, as Gastineau and



Ryngerson ('47) have already speculated. This appetite mechanism may very well be part of a broader pattern including possibly slower emotional growth: a lessened ability of the cortical-hypothalamic adjustment to develop new sets of synapses as the needs of the maturing individual demand. The connection of all this with the constitutional trend in a juvenile direction which the obese show in their morphology is more difficult. We may very possibly find that we are dealing on the one hand with genes which increase the total body growth rate and on the other with genes which through effects of adrenarche and menarche tend to end both physical and emotional growth earlier than usual, in addition to factors sensitizing the appetite mechanism to these slight growth differences and to environmental stress. Presumably genes for all three of these tendencies need to be present to produce a potentially obese person, who in any case need never develop actual obesity if properly educated with regard for his or her special sensitivities.

The diseases found in the obese put a further barrier in the way of cure, making prevention by far the best attack. Thus over one-quarter of the sample complain of pain resulting from hypertrophic arthritis (most frequently in the lumbo-sacral area) and the actual frequency of arthritic changes is certainly higher. This is probably linked not only with the general increase in weight but also with the abdominal ptosis (marked in 40-50% of the series) and consequent postural imbalance which Kerr and Lagen ('36) have shown to develop in obesity and to help to produce the dyspnea, cardiac embarrassment, dizziness and headache, shortened stature, and poor energy economy which all mark the present sample. Dyspnea, dizziness, and headaches each bring complaints in about one-fifth of the sample. Cardiovascular-renal difficulties, hypertension, gall-bladder disease, varicose veins, and episode of pneumonia, and some neurosis other than obesity each are present in about 10% of the series. Diabetes occurs in the mothers of 9 and father of one patient (but obese diabetics were themselves excluded from the series), and cardiovascular



affections are also frequent among the parents. Sensitivity to these afflictions and the obese shortness of life are possibly less the simple results of obesity than constitutional weaknesses inherited or developed by some of the same factors which produce obesity. Further research will be needed to determine which psychological or somatic variants of the obese are most easily cured. Table 8 suggests that extreme endomorphs who are offsprings of *average*  $\times$  *average* matings lose weight less easily than those higher in mesomorphy.

#### CONCLUSION

We have seen (1) that obesity tends to develop in early maturers inheriting a slightly juvenile type of body build; (2) that obesity is inherited and is determined by one or more genetic complexes perhaps affecting both (a) childhood growth rate and (b) time of maturity in such a way as (c) to sensitize the hypothalamus-mediated appetite mechanism and (d) to produce a slight infantile trend in body build; (3) that the unaggressive personality of the obese is not only tensed by anxiety but also in an "infantile" fashion peculiarly dependent on the love of others and extra sensitive to rejections and frustration to which the personality reacts neurotically by seeking oral pleasure to excess; (4) that a number of unsolved frustrations are present both in the childhood and adult lives of the obese, frustrations concerning personal relationships more frequently than economic difficulty.

Points (1) and (2) above may very plausibly be attributed mainly to genetic causation and point (4) to the challenging, crowded, and overcompetitive system of statuses in our American society. But (3) the "oral" personality of the obese, like the even more dependent or brittle personalities of the alcoholic or gastric ulcer patient, is obviously a result of childhood and later conditioning in which both heredity and the social environment play parts. Which of these plays the more crucial role?

The answer is also crucial, since cure of obesity depends on changing the oral habits if not the whole personality of

the obese. Data are not yet sufficient for a good estimate. Only if we had sufficiently accurate control material and means of measurement of the degree of environmental frustration could we say just how much tougher than usual are the environmental difficulties of the obese. And only if we knew this could we judge how far the orality of the obese results from extra sensitivity of response to a "normal" environment, which the obese personality makes frustrating by being over-demanding of love from others; or how far a truly loveless environment, especially in childhood, conditions the dependent traits in the obese personality. On the basis of the present inadequate data the latter seems the stronger probability in spite of the apparently "normal" economic circumstances of the obese and the far more disastrous childhoods which in individual cases produce "normal" competitive personalities. To a great extent, therefore, obesity could be reduced in our society by the same social improvements which would reduce juvenile delinquency and alcoholism. The positive social usefulness of dependence, lack of aggression and "oral" curiosity have not been explored by our civilization.

This certainly does not mean that the somewhat dependent personality of the obese is likely to be entirely environmentally determined. From the standpoint of evolution the dependence of all human beings first on their parents and then on the rest of their social groups is just as essential a development as their neural specialization. And it is empirically certain that the retention of what in other, less social, animals are juvenile emotional traits has been just as important in human evolution as the human prolongation of physical childhood and the change in growth rates which produced the enlarged human brain and small face. Though environmental selection certainly played a necessary part in producing the emotional as well as intellectual and somatic specializations of human beings, the genetic complexes on which such selection operated are undoubtedly still variable in our modern populations and through recombinations might very plausibly

condition such slightly inflexible personalities and juvenile physiques as those of the potentially obese.

#### SUMMARY

1. Obesity is a physically dangerous disease whose precipitating cause is stress, frustration, and deprivation of love in the social environment. Obesity is thus a neurosis with widespread psychosomatic effects.

2. The 103 white women in the series studied came from large, economically just adequate, poorly intergrated, and partly foreign urban families, with an excess of girl children, generally were frustrated in their own marriages and child-rearing, produced an average of just over two children, and substituted food for love.

3. About one third of the subjects were fat in childhood and another third not until after pregnancy.

4. Stress on Italian, German, Irish (rather than British) ancestries fits both the immigration and social-religious pattern of a Middle Atlantic city and the predominance of Alpine and other Palaeolithic-derived physical types. There is zoological and experimental evidence suggesting Ice Age selection favoring massiveness and obesity.

5. Inheritance of the potentiality for obesity involves several gene complexes, mostly not recessive but probably including a sex-linked recessive semi-lethal. These probably control hypothalamic sensitivity as well as body build partly through genetic effects on speed and ending of child growth: the psycho-neural circle of reaction through which anxiety may increase appetite and delay satiety scarcely has the same effect in all personality or physical type variants (contrast the oral obese with the peptic ulcer group).

6. After allowing for excess fat covering the obese physique may be described as endomorphic, short and small-boned, and slightly juvenile, with long and deep trunk compared to rather short and tapering extremities, round head and face, small blunt nose, relatively good teeth, and frequent greenish iris pigmentation.

7. Temperamentally the obese appear slow, "oral," non-aggressive and dependent on the love and approval of others. But there is far too much tenseness to fit Sheldon's ('42) viscerotonic complex.

8. Particular combinations of loveless childhood conditioning plus oral personality plus slightly juvenile and early-maturing growth pattern and morphology combine to produce the potentially obese person. Further research is needed to discover the relative roles of early conditioning and heredity in producing different variations of physique and personality in the obese.

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## PLATES

### EXPLANATION OF PLATES

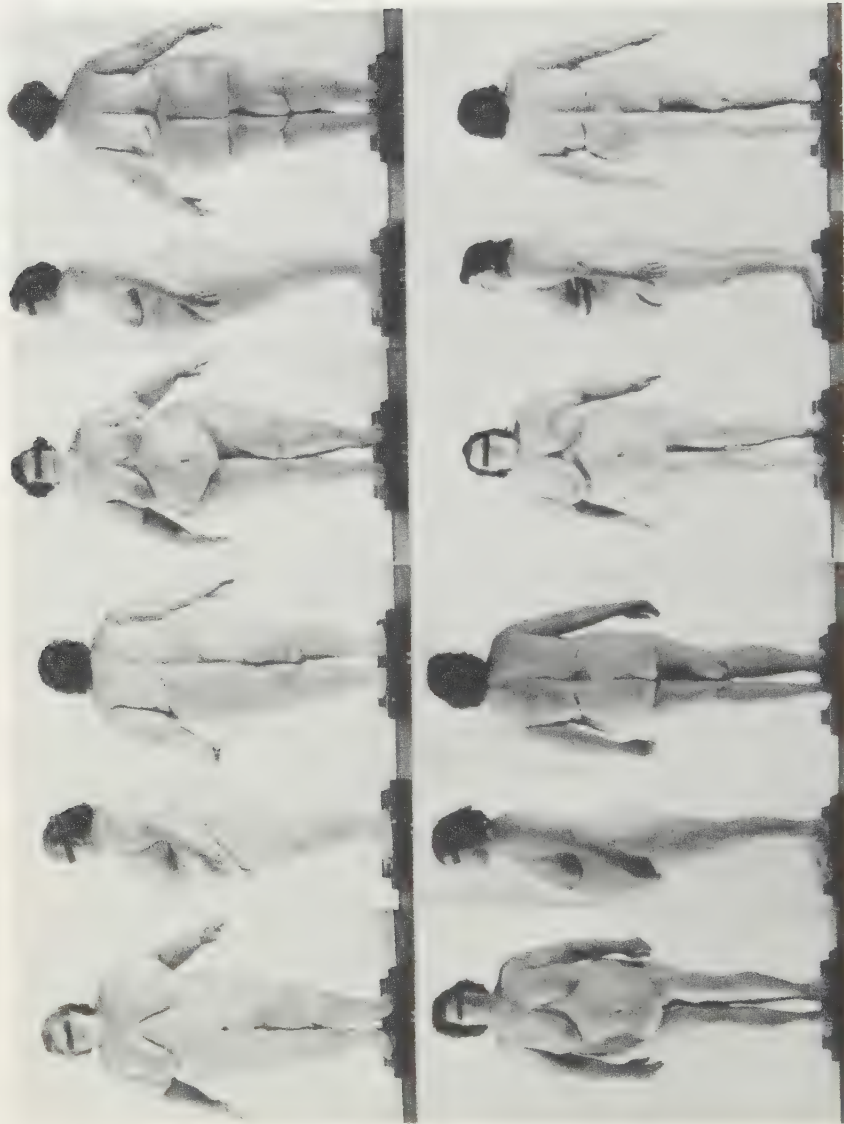
These illustrations are designed to show the range of somatotype variation found in the Jefferson Hospital obese series without indicating the relative frequency of variants: this is covered in table 3. The 8 examples are chosen also to show as far the possible the direction of variation in dysplasia, in androgyny, and in amount and pattern of subcutaneous fat.

Subjects were posed by being asked to copy the position shown to them and were not made to extend their arms with full muscular tension nor to stand as rigidly erect as they could. Their postures, therefore, are some indication of temperament but are not comparable with more rigorously posed somatotype photographs.

By definition the subjects are overweight for their body builds. For this reason as well as the lack of standards of comparison for the middle-aged female, all somatotyping of the sample is extremely tentative. The second component is especially subtle in this sample where a vigorous, energy-using exercising of muscles is not characteristic.

No. 64 is an extreme endomorph and No. 101 an extreme endomorph with ectomorphy dominating subsidiary mesomorphy. Nos. 151 and 197 show the effect of increasing mesomorphy. Nos. 89 and 36 are moderate endomorphs with slightly greater increase in mesomorphy. No. 72 shows domination of low ectomorphy by a balanced combine of the first two components. And No. 163 is an "average" middle-range combination.

The juvenile fat pattern appears in Nos. 64 and 151. No. 89 shows fat extremities rather than trunk. Nos. 197 and 101 show concentration of fat in upper and lower body regions respectively. Nos. 72 and 163 fit the "trochanteric" pattern, and No. 36 the average female fat pattern.



First component dominant. Upper left (64): extreme endomorph with juvenile fat pattern. Upper right (101): ex-  
treme ectomorph with juvenile fat pattern. Lower left (111): marked



First component strong. Upper left (89): mesomorphic moderate endomorph with fat extremities. Upper right (72): balanced endo- plus mesomorphy dominating very low third component, with trochanteric fat pattern. Lower left (36): mesomorphic moderate endomorph with average female fat pattern. Lower right (163): average "balanced" somato-type with trochanteric fat pattern.





INSTRUMENTS MANUFACTURED IN ARGENTINA.—The following has been abstracted and freely translated from a notice appended to "RUNA: Archivo para las Ciencias del Hombre," vol. 1, pts. 1-2, 1948 (Buenos Aires):

The Institute of Anthropology of the Faculty of Philosophy and Letters (Universidad de Buenos Aires) has dedicated a great part of the first year of its existence (1947) to solving [the problem of the scarcity of anthropometric instruments] . . .

Today we have the pleasure of notifying colleagues that the results of our efforts are in view. They consist of the first examples of a series of three instruments constructed in Buenos Aires, by order of this Institute, in the shops of an industrial firm of recent establishment. This firm is perfectly equipped to produce precision apparatus and employs engineers, draftsmen and workers trained in Europe in this type of delicate work.

The series of which we speak consists of three instruments, all applicable to craniometric techniques. They are: (1) a spreading compass, (2) a sliding compass [both Broca style] and (3) an acrometer [designed by Imbelloni to measure head height, especially in the living]. . . .

The three instruments that we have just mentioned constitute the principal contents of a leather case of modest dimensions and light weight. It is entirely practical for trips and excursions and is supplemented by a metal tape, skin pencil, etc.

Until now the initiative for such construction has benefited the laboratory of this Institute as well as the laboratory of the Institute of the same name of the University of Tucumán.

The Institute must contemplate the necessity of recommending to the manufacturing firm a quantity of series, the production and sale of which will compensate for the work and cost of manufacture of the instruments . . . .

Anthropological laboratories of this country and abroad that desire to give advance notice of acquiring equipment as described in this leaflet should indicate the museum material that they are prepared to give in exchange (archeological and ethnological collections, publications, etc.). These should be carefully listed as to quantity, quality, and positive value, since this institution neither can nor will receive in money the price of instruments. The latter is equivalent to 1,000 pesos in the Argentine national currency.

In the year 1949 the second stage will be prepared, namely, the study and construction of instruments indispensable for measurements on the living.

Orders for, and information concerning the series presently available should be directed to the Instituto de Antropología de la Facultad de Filosofía y Letras, calle Moreno 350, Buenos Aires.

## BRIEF COMMUNICATION

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### ANTHROPOMETRIC INSTRUMENTS

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#### ONE FIGURE

In the March 1947 issue of this journal, I described two calipers made by The Swann Tool and Machine Company of Hartford, Connecticut. These instruments, although a little light in weight, cost only \$7.50 apiece and are accurate and adequate for general use. The Swann Tool and Machine Company has agreed to continue the manufacturing of these cheaper instruments and orders are being supplied from all over the world. They have also agreed to make other calipers after the same pattern but using a heavier metal to make them comparable to the standard calipers now in general use. Thus, in the near future, there will be two types of calipers for sale by the same company.

Recently this company has completed the manufacture of the Anthropometer pictured in figure 1. The 4 sections are made from a bar of aluminum alloy. The entire bar is 2 m in length. One side of the bar is countersunk and a standard measuring tape is inlaid into the groove. The steel measuring tape is held in place by 4 drive screws in each section thus fastening it securely to the bar. The small parts of the Anthropometer are made of stainless steel which assures against rust and tarnish. The cross bars are not graduated as in the Martin Anthropometer, but the arms are reversible and the top one or two sections can be used as calipers similar to the standard anthropometer since a second tape is inserted in the reverse side, numbered from 0 to 1000 mm.

The entire weight of the Anthropometer including the carrying kit equals 3.5 pounds, which is similar to the Martin Anthropometer. This new instrument is now available at The Swann Tool and Machine Company, 30 Bartholomew Avenue, Hartford, Connecticut. The price,

including the heavy canvas kit which contains leather holders for each part, is \$35.00. If desired, it should be ordered directly from the company.

These instruments were developed with a grant given by The Viking Fund. For this the author is grateful.

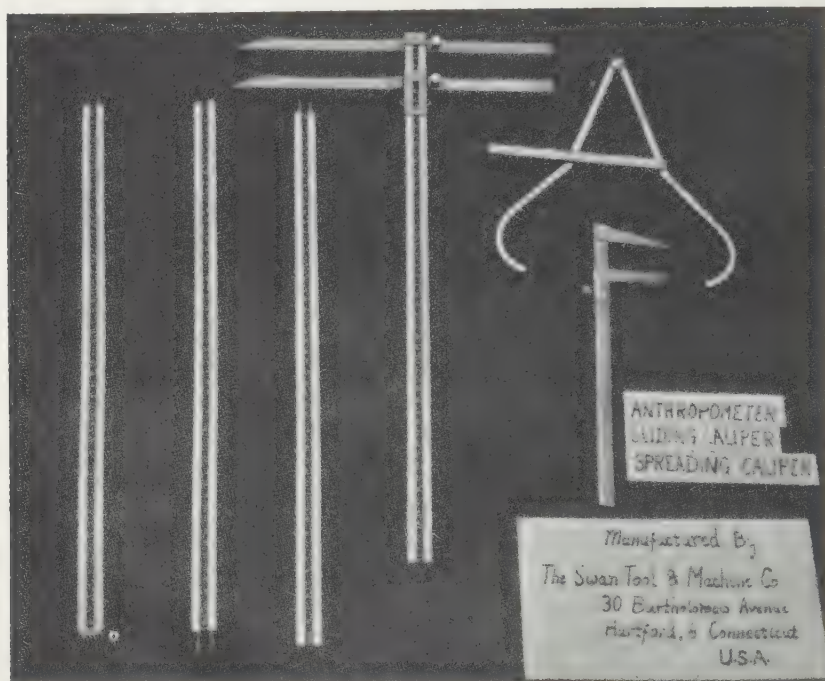


Fig. 1 Anthropometric instruments made by The Swann Tool and Machine Company, Hartford, Connecticut.

## REVIEWS

GENERAL ANTHROPOLOGY. By HARRY HOLBERT TURNEY-HIGH, New York. Thomas Y. Crowell Company. xx + 581 pp., 125 illus., 24 maps and charts. 1949. \$4.00.

Textbooks may be examined in light of their avowed purpose. Both the selection of a particular purpose and the degree and manner of accomplishment of that purpose are important. Turney-High intends "a general rather than a partial or intensive view" of anthropology. In doing so he assumes, with much justification, that the notion of culture should take primary stress. But with less justification, in terms of contemporary, general anthropological practice, he construes the scope of culture in a restricted way. He stresses the *continuity* of (material) culture by giving large space to Old World archaeology, and *variation* of (mostly material) culture by devoting much attention to "comparative ethnography." This is an acceptable but limited procedure. Portions of anthropology which received much general attention during the past decade are ignored or underplayed in *General Anthropology*. Systematic considerations, for physical anthropology, of constitution and human genetics, and, for cultural anthropology of acculturation, community and national studies, culture and personality, and applied anthropology, were not designed into the Turney-High text.

An assumption basic for *General Anthropology* is that "the undergraduate student should be grounded in descriptive facts before being launched into theory." Because the field is extensive, some selection of subject matter must be made for an elementary text. A selection which favors "facts" over "theories" is common in American anthropological teaching. The anthropologist who thus dodges all or most pertinent theoretical analysis, who "lets the 'facts' speak for themselves," simply presents his subject (as Philipp Frank has pointed out for physicists) within a framework of some unanalyzed "chance theory," often a crude or obsolete one. Turney-High has not produced a text which favors open discussion and understanding of the way anthropologists order and interpret their observations. Although the neglect was deliberate, the problem of the operational nature of the symbols used and the kinds of relationships which hold between these symbols will remain for many undergraduates, if not for their instructors.



Pages of physical anthropology (46) total about 11% of the book. The two recent texts comparable in general intent give more: Boas *et al.*, ('38) has 18%, and Kroeber ('48) gives 22%. Aside from a few statements appropriately incorporated in the sections on archaeology and ethnography, material on physical anthropology is collected in Chapter 2 on "The Organic Man," (with sections on Elements of Human Osteology, Anthropometry, Man's Zoological Rank, Distinguishing Characteristics of the Primates, and Fossil Primates) and in Chapter 3 on "Races, Ancient and Modern" (with sections on Fossil Races of Man, Modern Races, and Relationships of Fossil Races to Living Man). References for these two chapters include titles of 22 books and 18 papers in a terminal list. A number of useful terms are defined briefly in the Glossary-Index. These materials on the biological aspects of man receive a recondite and inert treatment unfortunately standard for most of our university courses in physical anthropology.

Chapters 2 and 3 contain a number of small slips (I counted 58 such) ranging from a misspelling of Earnest Hooton (pp. 28, 543), and a misnumbering of the Würm or 4th glacial (p. 40), to a misleading statement on the cranial capacity of the Veddah, which averages for adult males much closer to 1250 cm<sup>3</sup> than to 960 cm<sup>3</sup> (p. 35). In perpetuation of a curiosity of anthropological illustration, Neanderthal man (p. 42) is devoid of his scapulae (although other parts not recovered with the La Chapelle aux Saints specimen are supplied). "Embryology" (p. 573, glossary) is strangely restricted to viviparous organisms thereby excluding the oviparous chick, the chief object of embryological observation since Aristotle. Such slips are relatively harmless and are not of sufficient importance to warrant a full listing. Examples of items of more concern are (*cf.*, pp. 27-28) failure to mention tarsiers (Wood Jones is a reference!) in his classification of Primates and failure to use the rich material available (Carpenter, etc.) on the social behavior of the anthropoid apes (contrast pp. 32, 60-61). This last is especially noteworthy in view of the author's announced emphasis on the continuity of human behavior from remote times.

Turney-High *General Anthropology* is much the same book that is anticipated in his Preface — material, "factual," archaeological, and ethnographical. It has the real merit of being not large. There is need for a general introductory text in anthropology which fits the time limits of a single Quarter or Semester. Instructors who plan their courses short, factual, archaeological and ethnographical should investigate.

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THE EAST GREENLAND ESKIMO DENTITION, NUMERICAL VARIATIONS AND ANATOMY. By P. O. Pedersen. Meddelelser om Grönland, vol. 142, no. 3, Copenhagen, Bianco Lunos Bogtrykken. 256 pp., 58 tables, 27 figures, 30 plates. 1949. \$5.00.

"The East Greenland Eskimo Dentition" is a thorough, well documented, easily read comparative odontography, a result of 15 years of study. In this monograph, the East Greenland Eskimo are made the basis for discussion of all the gross morphological units of the dental mechanism.

The book opens with a general historical and geographical introduction of Eskimos, and gives particular emphasis to the origins of the East Greenland Eskimo. Dr. Pedersen disagrees with Seltzer's statement regarding the racial mixture of the inhabitants of the east and west coasts of Greenland. He contends that "Early white admixture in West Greenland before the Eskimos moved to East Greenland is not entirely out of question, but at any rate, must have been extremely slight."

The Eskimo migrations to the east coast occurred in the 14th and 17th century. "While the Danish colonization of West Greenland dates from more than two centuries back, conditions are different in East Greenland. Here Danish colonization is no more than half a century old, and the Eskimo population has not received white admixture during that period, apart from a few cases well-known to the local authorities. The Angmagsslik Eskimo (of the east coast) were unknown until 1884 . . . were on the decline . . . and only numbered 245 individuals . . . In 1930 the population had increased to 832." It is principally these individuals and 525 Greenland skulls from both coasts that the author has used in his study of the Eskimo teeth.

This preliminary material is followed by two chapters; the first deals with dental numerical variations such as congenital absence of teeth and supernumerary teeth, and the second deals with the morphology of the permanent dentition and all its parts. Each dental character is taken up individually. A survey is given, replete with references to previous studies made by other odontographers. Their opinions and discussions are quoted or summarized. Then the author's investigations and findings are defined, and finally an overall discussion and summary of the particular character is given.

According to Pedersen the incidence of missing lower incisors is higher in proportion to the missing upper lateral incisors in the Eskimo than in white races. However, the whites have been reported to have a higher incidence of missing laterals. He found "remarkably few cases of congenital absence of mandibular second pre-

molars . . . . 36.6% of the natives examined showed elimination of one or more third molars," which is higher than in other racial groups. "Vestigial forms of third molars coincide with congenital absence of third molar in a definitely higher percentage of cases . . . This seems to indicate common causative factors to be involved in extreme reduction of size and congenital absence of third molars." Dr. Pedersen discounts the idea that absence of third molars is associated with lack of space for their accomodation. "The results seem to suggest racial affinity between the Eskimo and the people of Eastern Asia."

In his treatment of the anatomy of the dentition he has gone over the small, seemingly insignificant details with as much concern and thoroughness as the more obvious ones. This has already proved valuable to the reviewer, who found Dr. Pedersen's observations of facial cusps and pits to substantiate evidences of significance of related characters in the australopithecinae and certain fossil hominids.

To comment on all the findings of Dr. Pedersen in this large work would be almost to write another monograph. Hence a summary abridged from the one in the text, follows:

The East Greenland Eskimo dentition strongly suggests Mongolian affinities because of the following characters:

1. High incidence of shovel-shaped incisors.
2. Very low incidence of Carabelli's tubercle.
3. High incidence of three rooted lower molars.
4. The pattern of congenital absence of teeth.
5. The high incidence of congenital absence of third molars.

Racial characteristics supposedly typical of Mongolian stock and found in these Eskimo are:

1. High incidence of pronounced enamel extensions on the molars.
2. High incidence of enamel nodules (pearls) on the molars.

Primitive characters present in their dentition are:

1. Frequent retention of remote ancestral cusp numbers and crown patterns.
2. Large size of the pulp cavity and moderate taurodontism.

Characters generally considered "advanced" (or specialized):

1. Reduction in size of the posterior molars.
2. High incidence of vestigial third molars.
3. Frequent absence of third molars.

Other characters which the author considered of obscure significance are:

1. Occlusal pearl-like excrescences.
2. Common fusion of root branches.
3. High incidence of facial pits and grooves on lower molars.

4. High incidence of supernumerary facial and lingual cusps on the molars.

Dr. Pedersen concludes that the evidence substantiates the Mongoloid ancestry of the Eskimo.

The reviewer feels that this is an excellent basic work on dentition which should be of value to all students of anthropology. The huge bibliography consists of references of 350 authors and is probably the most complete available, covering with few exceptions practically every known work that has to do with this huge problem. These exceptions are mainly those that were not available in Denmark due to the recent war.

Works of this type are especially important in view of the significance of frequencies of characters in population genetics. In this regard it must be remembered that the report is primarily based on 860 individuals whose genic makeup funnelled through the original 245 in existence in 1884. An interesting extension of this study would be a breakdown of the statistics and characters into family groups and analysis along this line. The materials included in the book give additional evidence of some of the recent interpretative concepts of dentition.

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INDIAN KNOLL SKELETONS of Site Oh 2, Ohio County, Kentucky. By CHARLES E. SNOW. Univ. Kentucky Reps. Anthropol., vol. 4, no. 3, pt. 2, April, 1948, pp. 367-554.

One of the first tasks assigned to the reviewer when he became a temporary assistant to Dr. Hrdlička at the U. S. National Museum in 1924 was the preparation of the Catalog of Crania in which are included the Indian Knoll skulls (Proc. U. S. Nat. Mus., vol. 69, art. 5, 1927). How little was known generally in those days about this part of the C. B. Moore collection is reflected in the headings of the respective tables in this Catalog: "Kentucky Indian Crania (pre-white); Locality: Green River, Ohio County." Similar understatement as to the age of this population ("There is no indication that the tribe had contact with Europeans"), together with cultural misstatements ("Maize, squashes and probably beans were the principal plants cultivated") are contained in R. W. Leigh's report on the dental pathology (this Journal, vol. 8, 1925). The assumption that, like most Indians, those at Indian Knoll practiced agriculture, in-

duced Leigh to attribute their extreme dental attrition to the grit resulting from the grinding of corn with stones.

I mention these two publications partly because they are not in Snow's bibliography and partly to emphasize the change in viewpoint about this culture during the last 20 years. How erroneous the above chronological and cultural statements are became apparent about 1934 when Prof. Webb began exploring the Wheeler Basin for TVA. Indian Knoll soon was recognized as the type site of a culture characterized by flexed burials in shell mounds, accompanying which, as grave goods, were mainly elements of the atlatl. Pottery was absent. It is now believed that these Indians lived around 1500-2500 years ago. Since there is no evidence that they practiced agriculture, the grit in their diet probably came from shellfish.

The skeletons described by Snow include not only the original small series secured by Moore in 1915, but also the much larger series secured by the University of Kentucky beginning in 1939 — altogether 521 measurable skeletons and 475 measurable skulls. So far as I know there is only one other report that describes such a large series of Indian skeletons from a single site: Hooton's Pecos report. Unfortunately Snow's report is in some ways a disappointing imitation of Hooton's.

In order to emphasize the size of his series Snow gives a photograph showing all the material laid out in one room, and another showing 391 skulls arranged in tiers. Quite as impressive, however, are the folding tables attached to the back cover. When laid end to end these measure nearly 22 feet. Indeed, so much space is given to tables and photographs that the actual text between pp. 381 and 532 amounts to less than 50 pp. This means that the tables speak mostly for themselves: the text relating to cranial dimensions amounts to  $1\frac{1}{2}$  pp., that to cranial proportions to  $2\frac{1}{3}$  pp.

Obviously a major effort has gone into this study. By my own count a total of 144 measurements, including those that are paired, has been taken on each skeleton. These furnish 52 indices. Also about 211 non-metrical observations have been recorded. Considering the size of the series, the total number of recorded observations thus runs well over 100,000. The resulting statistics are formidable. In addition, following Hooton's example, all of the skulls were sorted subjectively into types.

In view of the effort expended it might be expected that considerable attention would be given to defining measuring techniques and observational standards. Again, following Hooton's example, this



subject is dismissed with the statement that "the accepted and usual osteometric techniques were carefully followed." Yet the very first measurement — glabello-occipital length — is still being taken in two ways. As for morphological observations, what is the medium weight of a skull? When is a vault "ill-filled?" Or how big, or for that matter what is, a largeinion? Why not report the sizes of the "exostoses in auditory meati [sic]"? And how useful are statistics showing that males more often have narrow ischiatic notches, narrow subpubic angles, submedium preauricular sulci, etc.?

One may question the wisdom of such detailed description when unaccompanied by comparisons and interpretations as in the present case. Snow does not answer the many interesting questions about the relationship of these early Indians to the groups that surrounded or succeeded them. (When questioned on this point Snow told me that Prof. Webb had stated in Pt. 1 that a separate section would be devoted to comparisons and interpretations. I have been unable to locate such a statement.) For instance, has the type survived? How does the type compare with Hrdlička's "Algonkin" or Neumann's "Sylvid?" On these points there is simply the statement that "the bulk of Indian Knoll skulls appear to represent a single type which has been called Typical" (p. 401).

On the other hand, Snow paints an incredible picture of the appearance of these Indians. Ignoring the role of the intervertebral discs, he interprets the lumbar index to mean that the lumbar curve was just the opposite of the white norm. He adds that "the high percentage of lumbar arthritis would indicate that these flat-backed, slightly stooped, bent-kneed people went about daily complaining of the 'misery'" (p. 392). Pictures of two mounted skeletons show nothing unusual.

Some of my criticisms of this work could be levelled at physical anthropologists in general. We go on reporting measurements in the way we were taught and in excessive as well as uncritical detail. We pay lip service to standardization and over-pad our reports in fear of being criticized for omissions. Accurate, standardized description is laudable and indeed essential to historical physical anthropology. Yet today it should be expected that a sense of problem be exhibited with, and made one of the prime reasons for, such description.

It remains to be said that Snow has given due attention to the broad problems of variability and pathology. In the latter at last he escapes from the restraints of anthropometric conventions. The



data and illustrations in this section are particularly useful. Also it is good to see the skulls properly oriented in the photographs.

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THE WAYS OF MEN. AN INTRODUCTION TO ANTHROPOLOGY. By JOHN GILLIN. Appleton Century Co., New York, xv + 649 pp., 1948. \$4.50.

Dr. Gillin has devoted 137 of the 615 pages of his book to the physical side of man, his origins, his races, his types and his individual differences, on the reasonable assumption that an understanding of culture and the cultural process must be preceded by an understanding of the culture-building organism. The contents of these pages, and the order of presentation suggest a condensed version of "Up from the Ape." Like the comparable portion of Kroeber's recent text, there is much information compressed into little space; Dr. Gillin has not padded his text.

After a first chapter on zoological classification and man's place in nature, there is a considerable discussion of primate and anthropoid characteristics in chapter 2. This is followed by a résumé of primate physiology, growth, perception and behavior. Chapter 4 includes the usual résumé of historical geology, and then goes on to discuss the *Dryopithecus-Sivapithecus* group, the newer finds from South Africa, *Pithecanthropus* and *Sinanthropus*, Neanderthal and the morphologically modern finds. In the chapter on genetics and race (chapter 5) the concept of race is fairly presented as an anatomic concept, then after a treatment of heredity in man, races are considered as hereditary groups and a classification abridged from Hooton is provided for the student. This is followed by a well-advised chapter on environment and physical type, with references to work by Boas, Shapiro and Lasker; several race-mixture studies are also reviewed in some detail. Chapter 7 discusses the important and interesting field of sex differences, growth and age changes in general, so that the student understands the biological basis of sex divisions of labor and age-grades.

Naturally, in a compilation of this character the necessity for simplification has led to some doubtful statements. Modern man is repeatedly limited to 4-cusped molars, and the shape of his palate is given as usually V- or U-shaped" (page 47). "Old world monkeys show no reactions to blood group tests" (page 49). "With a proper microscopic

technique it is possible to see that each chromosome in fact consists of a series of ultra-minute globules arranged in series, like beads on a string" (page 100).

Certain sections are either extremely terse, or perhaps not well worded. Thus the mechanism of Mendelian inheritance and the determination of sex is obscurely presented. Chapter 3, devoted to primatology, contains much advanced material that has not been pruned to the student's level, and it repeatedly introduces physiological, psychological, and physical terms without explanation or amplification. Unfortunately the first paragraph on page 49 will probably confuse some advanced readers as well as most elementary readers, for Dr. Gillin appears to state that purine metabolism depends upon a serological factor detectable by agglutination.

The author has wisely avoided setting himself up as an authority on fossil man, and he has followed Weidenreich to a considerable extent. Though it would have been well to have included more recent information on *Meganthropus* and *Gigantopithecus* and a larger and more complete selection of photographs of fossil forms, the student can gain a fair knowledge of pre-hominid and early hominid forms.

The text is spiced, from time to time, with pertinent comments about physical anthropology as a technique, and sly remarks about the characteristics of physical anthropologists. There is considerable reference to the cephalic index, statistical techniques, anthropometry and racial typing. Instead of adopting the dictum that "race is a myth," Dr. Gillin carefully and repeatedly explains what we mean by race, how studies of race and race mixture apply to human biology, and how races change in the course of time.

Since this book was designed as a beginning text in general anthropology, it should be judged on the criteria of sufficiency, readability, and completeness.

Certainly there is ample material for the elementary reader, even without supplementary lectures. Readability varies; there are several chapters like those on primatology, heredity and fossil man that are definitely hard going for the student. This necessarily follows from the author's attempt to include a comprehensive review of human biology, within a limited number of pages. At times explanations are few, and many new terms are introduced without explanation. Therefore the teacher who uses *THE WAYS OF MEN* as a text must have a good general knowledge of physical anthropology if he is to make use of the resources of the book.

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## ERRATUM

## Studies in Physical Anthropology

No. 1 Early Man in the Far East

Correct [Northern India] third line after figure 4, page 24, to read [Northern Burma]. Corrected sentence should read —

of Northern Burma, and the uppermost Silwalik deposits (Boul-



PHYSICAL ANTHROPOLOGY IS — that branch of the broader field of anthropology which treats of physical man . . . as an animal. — George A. Dorsey. *Physical Anthropology*. Science, n.s., vol. 6, no. 134, 1897, pp. 109–120.

— the biological investigation of man. — E. A. Hooton. The relation of physical anthropology to medical science. *Med. Rev. of Rev.*, April 1916, 4 pp.

— the study of man's variation [or] the research into man's anatomical and physiological variation. — Aleš Hrdlička. *Physical anthropology; its scope and aims; its history and present status in the United States*. The Wistar Institute, Philadelphia, 1919, 164 pp.

— the science, or rather a congeries of sciences devoted to comparative study of the physical history of man. — M. F. Ashley Montagu. *Physical anthropology*. In *Medical physics* (Ed. by Otto Glasser), The Yearbook Publishers, Inc., Chicago, 1944, pp. 1014–1031.

— the science devoted to the comparative study of man as a physical . . . being. — M. F. Ashley Montagu. *An introduction to physical anthropology*. Charles C Thomas, Springfield, Ill., 1945, xiv + 325 pp.

# THE BEARING OF THE AUSTRALOPITHECINAE UPON THE PROBLEM OF MAN'S PLACE IN NATURE<sup>1</sup>

WILLIAM K. GREGORY

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FOURTEEN FIGURES

In the history of anthropology the year 1925 A.D. deserves to be underscored, for it marks the publication of Professor Raymond A. Dart's article in *Nature*, wherein he described the fossil skull which he named *Australopithecus africanus*. His outstanding contribution to the problem of human origin may well be viewed against a mainly historic background, with special reference to the basic assumptions implicit in various theories of the ways in which the human stock has evolved from earlier stages.

## TELEOLOGISTS VERSUS EPIGENESISISTS

To the teleologists of the past and present the plan of creation has always preceded the thing created. This doctrine has been and is still deeply entrenched in multitudes of human crania. To the epigenesists on the contrary the plan itself originated and developed in time, as new factors came into the ever changing histories of living beings. But did the "plan" grow altogether by "Chance," that is by the accidental coincidence or intersection in time and space of all its causal factors? Or did necessity or "Law" continually limit and control the growth of the plan? A long-standing interest in the relations of Chance and Law has led me to

<sup>1</sup> Read at the Viking Fund Conference on the Australopithecinae, August 30, 1949.

infer: (1) that the phenomena called Chance are reflected not only in events falling within the normal curve of probability but also in the new or emergent events of evolution; (2) that Chance should not be contrasted or logically opposed to Law, but that both are merely different aspects of one continuous reality; (3) that "Law" connotes recurrent or relatively fixed limiting factors; but (4) the interaction of new and old factors may, by Chance, change the limits and create completely new combinations. As applied to the case of the skull of *Australopithecus africanus*, Chance, that is, the concurrence of many unique events, culminated in its fossilization, preservation and discovery; but Law, that is the recurrent factors, also led to the repeated search for others, to their coming into Professor Dart's competent hands and to his evolving knowledge of their significance.

The teleologists have accepted the dogma that Adam was created in accordance with a perfect, preordained plan. To the epigenesists on the contrary the human plan still shows many imperfections, partly the result of inherent liabilities incurred with the adoption of the upright gait. The dualists, believing in man's divine origin and contrasting matter with "mind" or "spirit," classify living things into two major groups: (1) man and (2) all other living things; no intergrades are recognized or admitted. However it might now be pertinent to ask: to which of these two categories is *Australopithecus africanus*, with his sub-human brain, to be referred?

The more far-seeing of the natural philosophers however gradually came to realize that there is a basic similarity in plan even between such different looking creatures as bipedal man and quadrupedal pig. Thus we find Descartes in his famous "Discours sur la Méthode" (1637) recommending that if any of his readers wished to learn about the plan of construction of the human heart he should get a surgeon (meaning a barber-surgeon) to dissect before him the heart of a pig.



The more or less intermediate appearance of monkeys between man and animals must have been realized by the European people who applied the name Capuchin to one of the South American monkeys. By 1693 monkeys were classed by John Ray, developing Aristotle's ideas, among the "*Animalia Vivipara, quadrupeda pilosa*" and were referred to one of the main divisions called "*Platyonycha ac Anthropomorphae*." Linnaeus (1759) developed this theme much further by inventing the word *Mammalia* (*mamma*, breast) as the name of the class and arranging its main divisions into successive orders, the order *Primates* being the highest. Carrying the old idea of an "*échelle des êtres*" to its logical conclusion, Linnaeus reverently placed the name of Jehovah at the apex of his *Systema naturae*. Below Jehovah were the archangels and angels. Man, in accord with the word of psalmist was ranked as a little lower than the angels. No objection to this allocation was then recorded.

#### PITHECOPHOBIACS

The order *Primates* of Linnaeus was however occupied not only by man but also by *Simia*, *Lemur* and *Vespertilio*. This was too much for some of Linnaeus' successors and we find Thomas Pennant for instance, in his "*History of Quadrupeds*" (1781) uttering the following complaint: "There are faults in his [Linnaeus's] arrangement of the *mammalia*, that is of animals which have paps and suckle their young, in which class are comprehended not only all the genuine quadrupeds but even the Cetaceous tribe, that oblige me to separate myself in this one instance from his crowd of votaries . . . I reject his first division which he calls *Primates* or chiefs of Creation; because my vanity will not suffer me to rank mankind with Apes, Monkeys, Macaucos and Bats, the companions Linnaeus has allotted us even in his last System."

This strikingly frank passage reveals the deep cleavage between what we may call the pithecophobiacs who are allergic to their poor relations and the pithecophilians, who

may even profess to be proud of their tailless simian ancestors. The pitheciophobiacs do not welcome such brutes as *Paranthropus robustus*, as that poor monster was recently sketched by Dr. Broom, and they are not at all cordial to *Plesianthropus africanus*, even when portrayed as an ape-man child of pre-Freudian innocence.

Blumenbach, the reputed father of anthropology, followed Linnaeus in referring man to the Class Mammalia, but he sought a middle course by assigning man to a separate order, which he at first named Inermis, but later changed to Bimana or more correctly Bimanus. Cuvier likewise isolated man under the order "Bimanes" and Illiger did the same, but called the order Erecta.

The isolation of mankind was more reassuringly taught by Richard Owen (1868), who assigned to man the rank of a subclass Archencephala, on account of the marked superiority of the human brain. But what, we may enquire, would Owen have done with Dr. Broom's *Plesianthropus*, whose brain capacity barely exceeded that of a large male gorilla?

To the pitheciophobiacs the deeper the cleft between man and the "brutal apes" the better, and it was a grave tactical mistake on their part to leave man anywhere within the class Mammalia. The pitheciophobiacs, outside of Clerical and Fundamentalist circles, have included: (1) certain anthropologists, trained to recognize and measure human racial differences, but distrusting all results relating to the evolution of man from lower primates; (2) certain anatomists, skilled in describing the most complex anatomical facts in static terms, but disregarding morphologic and palaeontologic evidence of evolution by transformation; (3) certain zoologists, keen in the search for diagnostic differences between man and apes, but resolute in classing resemblances between man and apes as mere "parallelisms" or "convergences."

Even more obdurate than the pitheciophobiacs are the confirmed statisticians, who ban all non-metrical data and deny both orthodoxy and respectability to those who prefer visual comparison of morphological patterns.

## PITHECOPHILIANS

Among the greatest pioneer pithecophilians were Lamarck, Darwin, Haeckel, Huxley, and Keith.

But it is seldom easy to classify independent, free investigators under any single label. Dr. Broom for example may be classed as a pithecophilian in so far as he regards the Australopithecinae as ape-men; but he sounds rather like a pithecophobiac when he rises to refute those who have concluded that the Australopithecinae represent an extreme southern derivative of the *Proconsul-Dryopithecus* group, or that man is not too distantly related to the chimpanzee and gorilla.

## IRREVERSIBILITARIANS

The pithecophobiacs have often emphasized the divergent "specializations" of the great apes and the allegedly "primitive features" of man. But in many cases what a man calls specialized and primitive will depend more or less upon his often unspoken assumptions and postulates. To irreversibilitarians for example, when a "specialization" is once acquired it can never be got rid of. To the epigenesists on the contrary, the essence of the transformation consists (1) not only in progressive emphasis in some old features but (2) also of the reduction and perhaps elimination of others, together with (3) the appearance of many wholly new features, not to be looked for below the given habitus level. Of course many former specializations have proved to be irreversible, such as the basic vertebrate and basic mammalian construction plans. But some specializations that were once new had to be sacrificed at every stage of advance. This is exemplified by the progressive reduction of the dental formula (of adults) from  $\begin{smallmatrix} 3.1.4.3 \\ 3.1.4.3 \end{smallmatrix}$  in primitive placental mammals, to  $\begin{smallmatrix} 2.1.4.3 \\ 2.1.4.3 \end{smallmatrix}$  in Eocene lemurs (*Notharctus*),  $\begin{smallmatrix} 2.1.3.3 \\ 2.1.3.3 \end{smallmatrix}$  in New World monkeys,  $\begin{smallmatrix} 2.1.2.3 \\ 2.1.2.3 \end{smallmatrix}$  in Old World monkeys, anthropoid apes, Australopithecinae and primitive man,  $\begin{smallmatrix} 2.1.2.2 \\ 2.1.2.2 \end{smallmatrix}$  in many modern men. Dahlberg's researches suggest that in some future time the typical formula may be reduced to  $\begin{smallmatrix} 1.1.1.2 \\ 1.1.1.2 \end{smallmatrix}$ .

## VECTORIANS VERSUS CLADOGENISTS

A still greater emphasis on the separateness in geologic time of supposedly related lines is expressed by Professor Leo S. Berg, who in his book "Nomogenesis" as well as in his classification of fishes likens the situation to the relation of the leaves to the back of a book. Those who subscribe to this and related theories might therefore be called phyllogenists (phyllon, leaf) or vectorians, in opposition to the cladogenists who visualize evolution as a branching process (clados) after the manner of Darwin. Some palaeontologists are essentially vectorians, because many of the branches in invertebrate palaeontology are far longer than those in mammalogy, including primatology.

## HOMUNCULISTS

The idea that *Tarsius*, or rather, some of its distant Eocene forerunners may be nearer to the ancestry of man than are the great apes, stems in part from the paleontologist Cope, who in 1881 described a certain very small fossil lemuroid Primate skull from the Eocene of Wyoming, which he named *Anaptomorphus homunculus*. After noting several features in common with man he suggested that this genus is nearer to the hypothetical lemuroid ancestor of man than any other yet discovered. Another contribution to what may be called the Homunculus theory of the origin of man was made by Hubrecht ('02) who noted that certain features of the placentation and embryology of *Tarsius* are remarkably man-like.

Boule ('08) in his memoir on the Chapelle-aux-Saints Neanderthal remains suggested that the name *Eoanthropus*, as invented by Smith Woodward for a large-sized human skull of Pleistocene age, was an unfortunate misnomer and that the true *Eoanthropus* would be found to be a very small erectly walking creature of Eocene age, with large eyes, expanded brain and small jaws. Ameghino seems to have had a similar idea for he gave the name *Homunculus* to a small fossil South American monkey with large orbits, which he



regarded as a remote ancestor of man; but this "homunculus" was shown by Bluntschli ('13) and later writers to be a true South American monkey, related to the douroucoulis (*Aotus*). Thus it seems fair enough to class Cope, Hubrecht, Boule and Wood Jones as homunculists, in so far as they all regarded such large-eyed, large-brained erect "little men" as a suitable starting point for *Homo*.

In *Tarsius* the great development of the eyes and the reduction of the olfactory parts contribute to its elfin appearance, while the animal's amazing power of leaping about among the branches implies an advanced development in muscular coordination and balancing and in the motor areas of the neopallium. It is not surprising therefore that Elliot Smith found in the brain of *Tarsius* a convenient structural intermediate between the less complex brains of typical lemurs and the still more complex brains of monkeys, apes and man. On the other hand Woollard ('25) in his report on the anatomy of *Tarsius* found it to be a "lemur of lemurs."

From a palaeontological viewpoint the known Eocene tarsoids and *Tarsius* itself are specialized side branches from a lemuroid base and are far more widely separated phylogenetically from the Australopithecinae and Hominidae than are the existing anthropoid apes.

#### PROTOPITHECOPHILIANS, ANTIBRACHIATIONISTS, ORTHOGENISTS

Those who regard man as a derivative or very early side branch of the Old World or catarrhine stem are neither pitheciophiles nor pitheciophobes. They may therefore be called protopitheciophiles. They oppose the idea that the remote ancestors of man were accomplished brachiators like the gibbons, which they regard as far too specialized to have given rise to man. Thus at least most of the protopitheciophiles are also anti-brachiationists in opposition to the brachiationists who regard the loss of the tail, the strengthening of the sacrum and the bipedal habit of running on the ground as having probably all been initiated by early brachi-



ators, related on one hand to the ancestral gibbons and on the other to the typical Dryopithecinae. Professors Schultz and Straus have amassed and analyzed a vast amount of accurate anatomical observations and measurements, which, they infer, indicates the extremely early separation of the human from the ape stem.

Somewhat similar conclusions have been reached by Professor Le Gros Clark, partly on the basis of his studies of the wide-ranging East African Lower Miocene primates, which were first discovered and described by Hopwood, Leakey, MacInnes and now, much more fully by Le Gros Clark. The latter is inclined to the opinion that the remote ancestors of man may eventually be connected with some pronograde, non-arboreal ape, possibly not unlike one of the Lower Miocene East African fauna, which includes *Proconsul*, *Xenopithecus* and other genera. The same authority also expresses his acceptance of the principle of orthogenesis and therefore may be classed with the orthogenists in opposition to those who still believe in branching evolution.

In general, pithecophobiacs, irreversibilitarians, vectorians and homunculists prefer to set aside all the known fossils as possible ancestors of man, and they usually disregard the fact that the different members of any widely varying order such as the primates always seem to preserve successive grades of growth or emphasis of any given part. After throwing out the known fossils and all the existing forms the pithecophobiacs proceed to conjure up an entirely unknown series of hypothetical animals of which every one had successfully avoided all "specializations." Thus their favorite fallacy is the *ignotum per ignotius*.

#### THE AUSTRALOPITHECINAE AND THE EVOLUTION OF THE HUMAN FOOT

Both comparative and paleontological evidence indicate that, in the more primitive Lower Eocene and Paleocene representatives of the Carnivora, Condylarthra, Edentata and other early Placental orders, the extremities were 5-rayed

with short spreading metatarsals and moderately divergent first metatarsals and digits. Among the earliest known primates, including primitive lemuroids (Notharcids), tarsioids (*Washakius*, *Necrolemur*), the metatarsus of the hallux was strongly divergent, ending proximally in a large olecranon-like process. When this strongly grasping foot is fully extended it is seen to consist of a large inner branch, the hallux, and a still larger lateral branch, comprising the second to 5th metatarsals and digits. I have named this the biramous type of foot. It is fully preserved in its primitive state in all the diverse modern lemurs of Madagascar, as well as in their upper Eocene ancestors the European Adapidae. This type is approached but not fully developed in the modern tree shrews which are regarded as very primitive survivors of the basal lemuroids. In *Tarsius* also the hallux is divergent and the grasping ability is enhanced by the disc-like expansion of the distal ends of the digits.

The biramous grasping foot is preserved with minor modifications in all the ceboid monkeys; in the marmosets we find it in a somewhat weakened state. In the catarrhine monkeys, the olecranon-like process of the first metatarsal is somewhat less prominent and the hallux can be moved more freely from side to side, whereas in the primitive lemurs the extended proximal process fits into a deep depression in the middle of the tarsus and its lateral mobility is sharply restricted. The anthropoid apes have lost the olecranon-like process but they retain the essentials of the biramous character of the hind foot. This gives them thumb-like great toes and the right to be called *Quadrumana*, although the deep structure of this hand-like foot is of course radically different from that of their hands.

In view of the wide-spread distribution of this biramous, grasping type of foot, from the primitive Eocene lemuroids to all the modern lemuroids, *Tarsius*, ceboids, catarrhine monkeys and anthropoid apes, I inferred ('16-'20) that it is one of the most ancient "basic patents" so to speak, of the entire Primate Order and that its apparent absence in

man is due to the remodelling of the foot in the course of adaptation to the upright posture and gait. Quite independently Weidenreich ('21) had concluded that the transformation of an ape-like grasping foot into the human stage could be clearly visualized as parts of the adaptation for walking erect; that is, in the period when the legs were straightened, the lumbar curve emphasized, and the skull drawn backward above the fulera of support (acetabula).

Elftman and Manter ('35) very clearly analyzed the movements of the components parts of the foot around certain axes and showed that, when the ape foot is turned partly inward as in climbing, its parts assume positions which would seem to be favorable starting points for the various new specializations of the human foot. In brief their work suggests that, in the ape-like ancestors of man, neither the longitudinal nor the transverse arch of the foot were allowed to flatten down against the ground as they do now in the gorilla, but that, as these arches were held by muscles and tendons in the curved grasping position, the great toe was drawn toward the others and twisted so as to face downward rather than inward; thus the running power of the foot was greatly improved.

Another source of morphological evidence for the reality of the transformation of an ape-foot into a human foot was developed in the beautiful series of comparative dissections (figs. 1, 2) of the feet of apes and man prepared by the late Henry C. Raven. Under his supervision was also prepared an exhibit of carefully labelled casts, showing the bones, muscles, tendons and ligaments of the foot of gorilla, chimpanzee and man.

A comparison of the bones of the foot of gorilla and man indicates that in order to convert the basic anthropoid into the human type it would be necessary to make a series of closely correlated changes, two of which may now be noted: (1) the facet on the entocuneiform against which the hallux abuts would have to be flattened; (2) the long axis of the

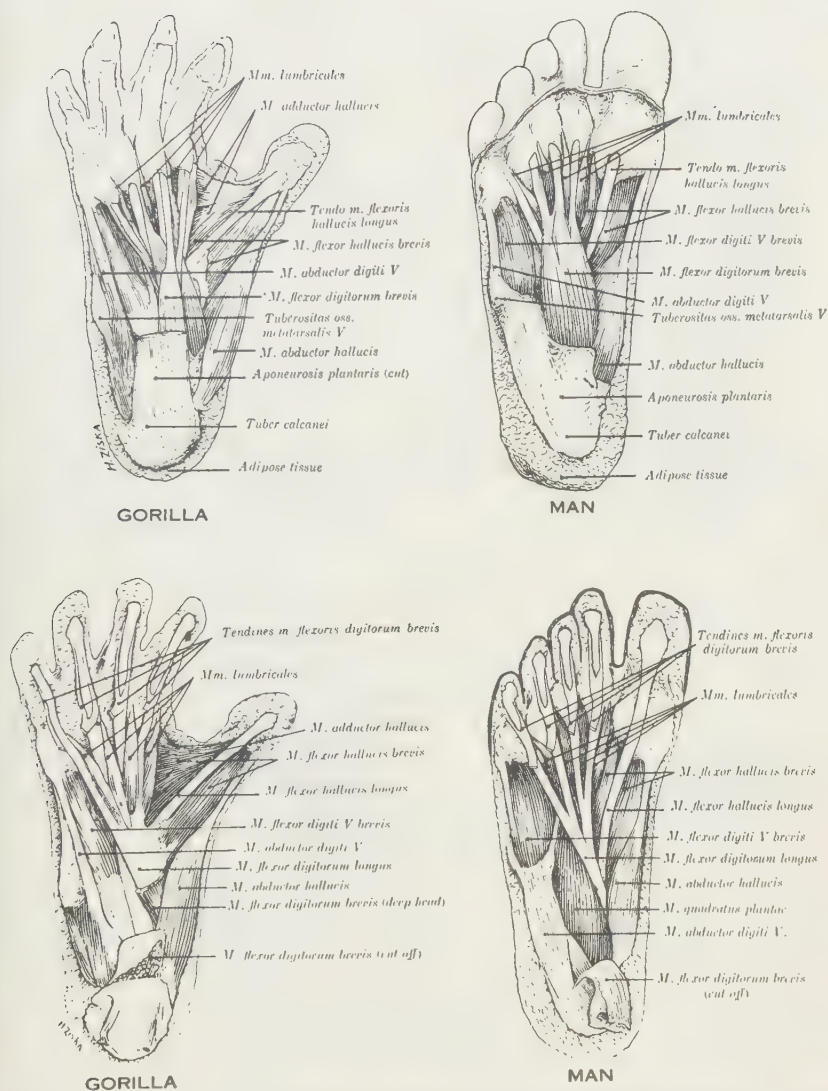


Fig. 1 Dissections of plantar musculature. First and second layers. After H. C. Raven.



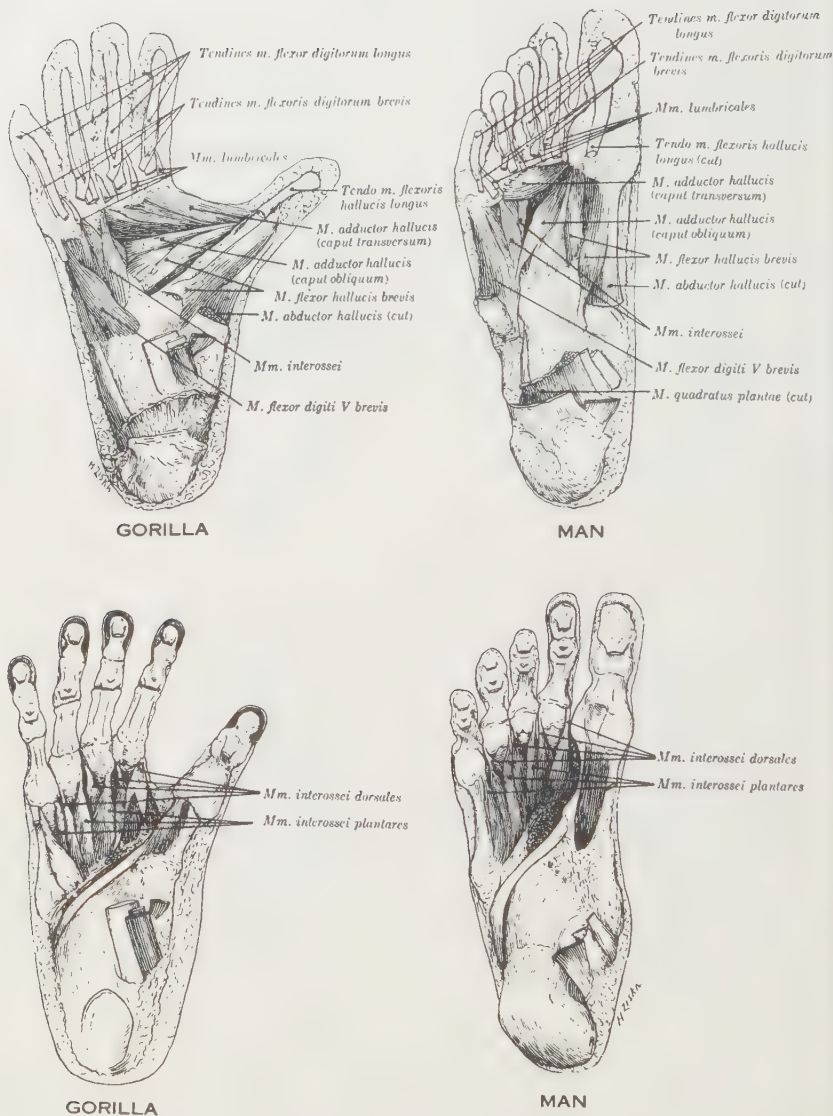


Fig. 2 Dissections of plantar musculature. Third and 4th layers. After H. C. Raven.



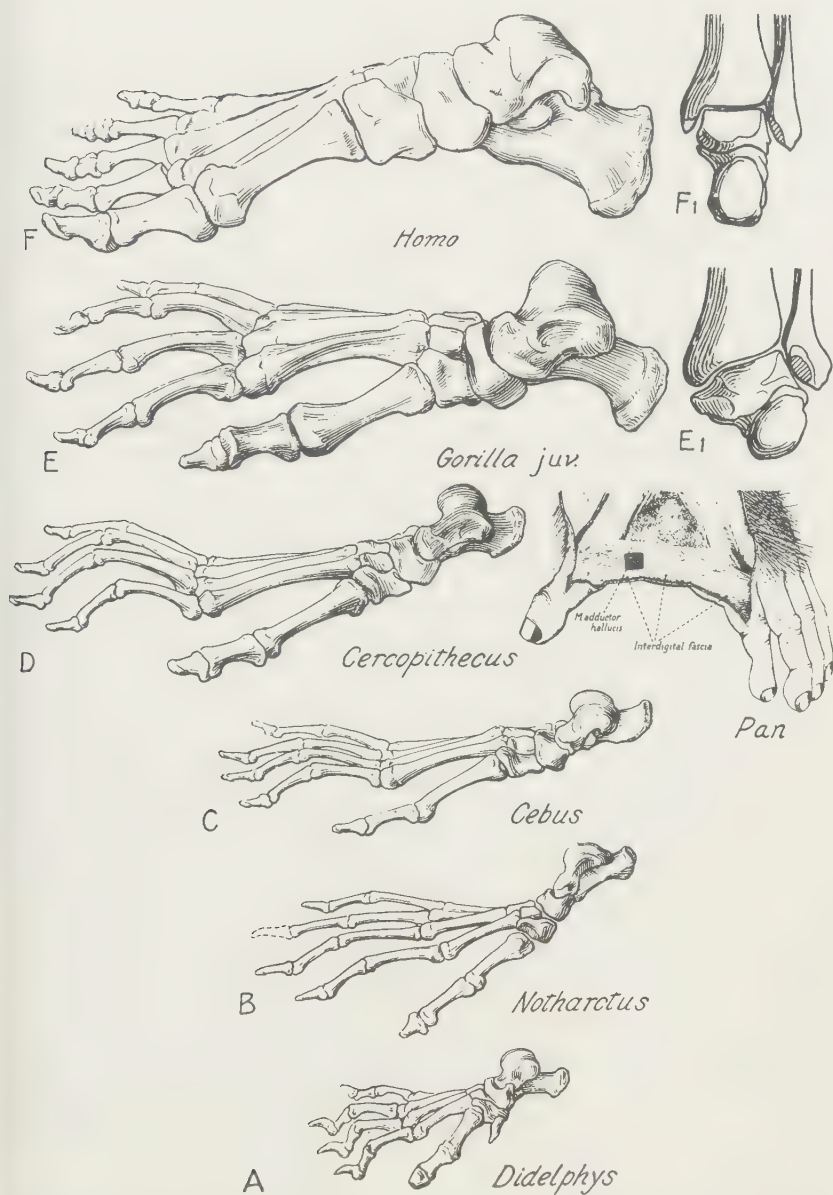


Fig. 3 A-F, right pes, oblique inner view. After Gregory. E1, F1, Right pes of gorilla and man, rear view. From M. Weber after Topinard. Left pes of chimpanzee, to show interdigital fascia. After H. C. Raven.

hallux would be turned and twisted so to be directed forward and downward.

Now it has been shown by Professor Schultz that in foetal and adult gorillas and men there are considerable ranges of variation in both the curvature of the entocuneiform-metatarsal facet and in the direction of the long axis of the metatarsal; so that the differences which distinguish gorilla and man in these features may be regarded as quantitative rather than qualitative. Secondly the first metatarsal of man is closely tied to those of the second and other digits by the transverse metatarsal ligament, a unique feature in man. But Raven showed that in the chimpanzee and gorilla there is a mass of collagenous inelastic connective tissue lying in the thick web between the first metatarsal and the other digits. He suggested that as the gap between the hallux and the second digit was closed the connective tissue gave rise to the transverse ligament between the hallux and the second metatarsal. Such a transformation would imply a marked change in the direction of evolution and it would therefore probably be unacceptable to the irreversibilitarians; but it seems no more remarkable than other rather well documented major transformations, such as the transformation of reptilian forearms into avian wings. Such profound changes of function usually imply equally radical changes in proportions, often with creation of new ligaments and trochleae for restricting motion within certain limits.

Although the construction of the foot of the Australopithecinae is not yet satisfactorily known, their evident adjustment to upright gait in the forward position of the occipital condyle may conceivably have been correlated with an equally human construction of the foot as a whole. Indeed the talus of *Paranthropus*, as described by Broom ('46) is on the whole definitely nearer to the Bushman than to the gorilla type, but the much greater transverse arc of the facet for the navicular as seen in the top view suggests a greater flexibility of the foot itself.

In short, comparative studies of the bones of the extremities in monkeys and apes appear to support the inference that the orang is a heavy bodied arboreal brachiator, the chimpanzee and gorilla partly secondary ground apes and the Australopithecinae and man bipedal striders of the open plains.

THE OLDEST KNOWN APE (PROPLIOPITHECUS)  
AND THE AUSTRALOPITHECINAE

The primitive catarrhine stock, which probably included only pronograde monkeys, evidently lies far below the near-human horizon of the Australopithecinae, with no known intermediates. On the other hand the oldest known anthropoid ape stage, *Propliopithecus* from the Lower Oligocene of Egypt, although represented only by a small, incomplete lower jaw, has very well preserved and primitive cheek teeth. It was seen by Schlosser and his successors that the lower teeth of *Propliopithecus*, while contrasting sharply with those of monkeys, appear to supply a structurally ideal ancestral stage: (1) for those of the Lower Miocene African *Proconsul* group, (2) for the European Miocene *Pliopithecus* and the gibbons, (3) for the diversified European and Asiatic Dryopithecinae. The body of the small mandible of *Propliopithecus* is relatively short and deep and the strength of the masticatory muscles must have been great in proportion to the size of the cranium, a characteristic ape-feature. Thus *Propliopithecus*, as far as it goes, tends to indicate that the Australopithecinae and the Hominidae belong in the anthropoid division, the earlier (Oligocene) members of which were not very remotely related to the gibbons and were presumably arboreal and not yet ground-living apes.

DENTAL ARCHES AND TEETH

The dental arches and deciduous teeth of *Australopithecus africanus*, as Professor Dart originally noted, present striking evidence of close relationship with man; nevertheless the

lower molars also have retained the basis *Dryopithecus* pattern of three outer cusps and two inner ones, separated at their bases by a special and characteristic system of grooves. The permanent molars of *Australopithecus prometheus* are very massive. In the great thickness and size of the body of the

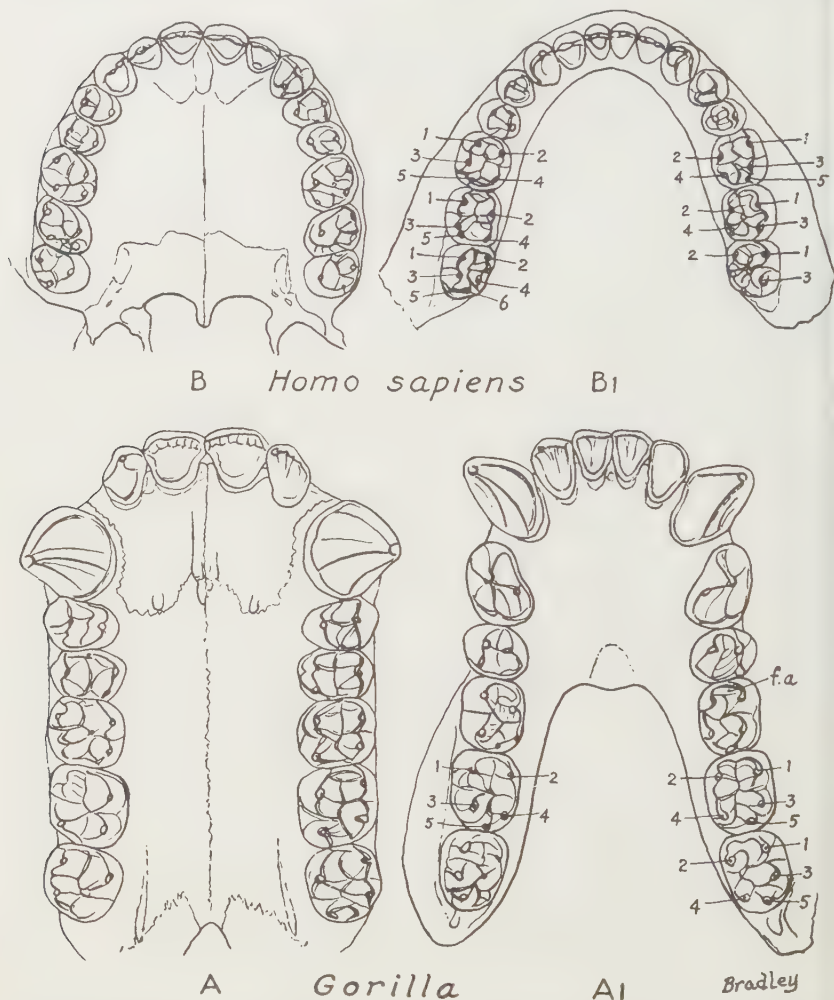


Fig. 4 Extremes in dentition, palatal and mandibular arches. From Gregory after Röse. 1, protoconid; 3, hypoconid; 5, hypoconulid; 2, metaconid; 4, entoconid; 6, cusp 6; f.a., fovea anterior.

mandible the Australopithecinae resemble the recent and fossil great apes. In the latter the huge jaws and great muscles are used in breaking off, piercing and cutting large fruits with tough rinds, as in the orang, or chewing the sugar cane as in the gorilla; the latter also strips the surface of certain stems by pulling them transversely through his mouth across

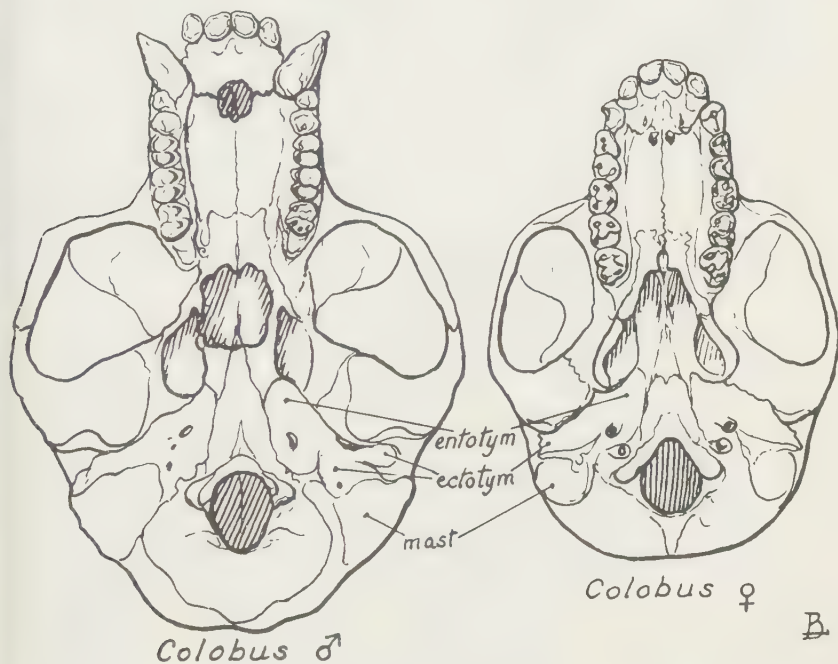


Fig. 5 Contrasts in dental arches: Male with large canines, large diastemata, spreading arch, and wide bizygomatic spread; female, with small canines, no diastemata, narrow arch and narrower bizygomatic spread. After Gregory.

his canines to get at the chlorophyll. The mountain gorilla carries huge loads of vegetation in his digestive tract and is essentially a herbivore; but the two captive gorillas in the New York Zoological Park have been conditioned to like meat. In view of the food habits of Australian aborigines and African pygmies it would hardly be surprising if the Australopithecinae, in addition to killing baboons and cracking open their skulls to get at the brains, were also general



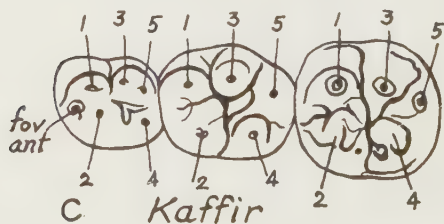
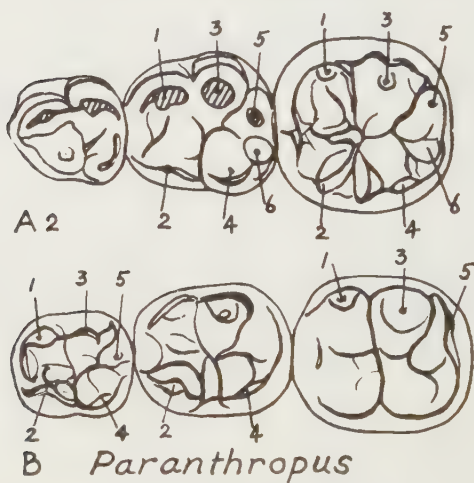


Fig. 6 Palatal and mandibular arches, with deciduous teeth and first permanent molars of *Australopithecus africanus*. From Gregory, after photographs and casts supplied by Professor R. A. Dart.

Fig. 7 Deciduous teeth and lower of: B, *Paranthropus robustus*; C, modern Kaffir. After Broom.

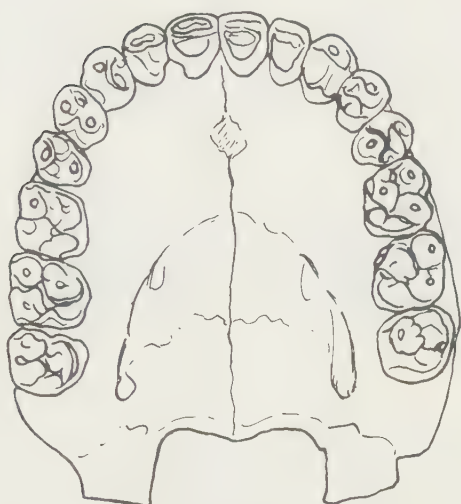
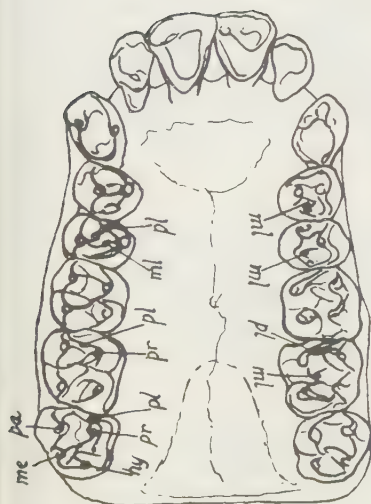
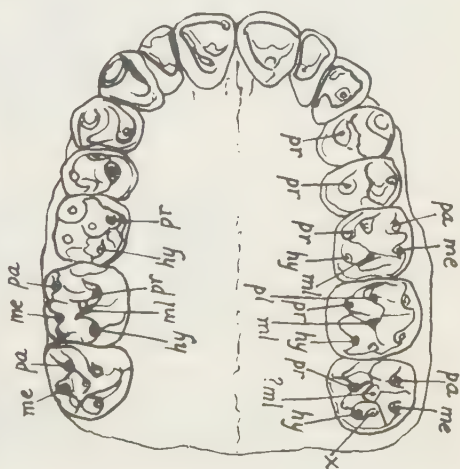
C *Homo* (Heidelberg restored)A *Sivapithecus* ♀ ("Dryopithecus")B *Plesianthropus* ♀

Fig. 8 Restorations of palatal arches. After Gregory and Hellman (A, B); McGregor (C). *pa*, paracone; *me*, metacone; *pr*, protocone; *hy*, hypocone; *pl*, protoconule; *ml*, metaconule.

feeders or even in part carrion feeders, alert to snatch away from the vultures the remains left by lions and hyaenas. The lack of a simian shelf is a point of contrast between the Australopithecinae and the modern anthropoids. But there

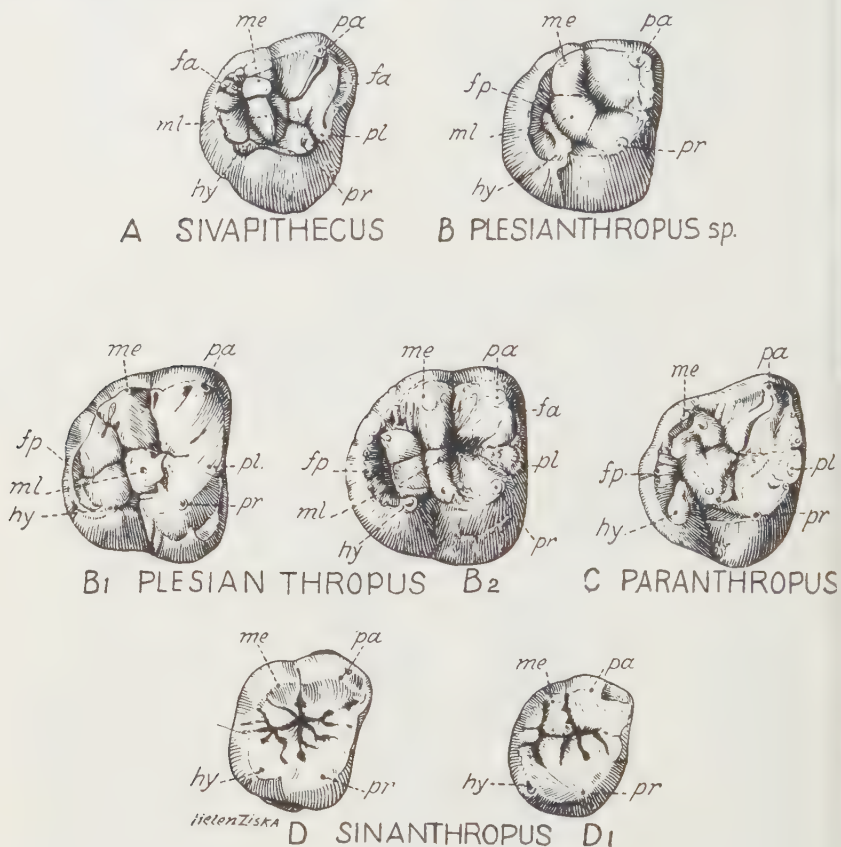


Fig. 9 Right upper third molars. A-C from specimens and casts, D, D1 after Weidenreich.

is no simian shelf in *Dryopithecus*, *Sivapithecus* or *Proconsul* or allied forms, and this feature is poorly developed in the jaw of certain female gorillas.

Adloff rules the anthropoids out as ancestors of man, because the males have large tusks. But Gregory and Hellman

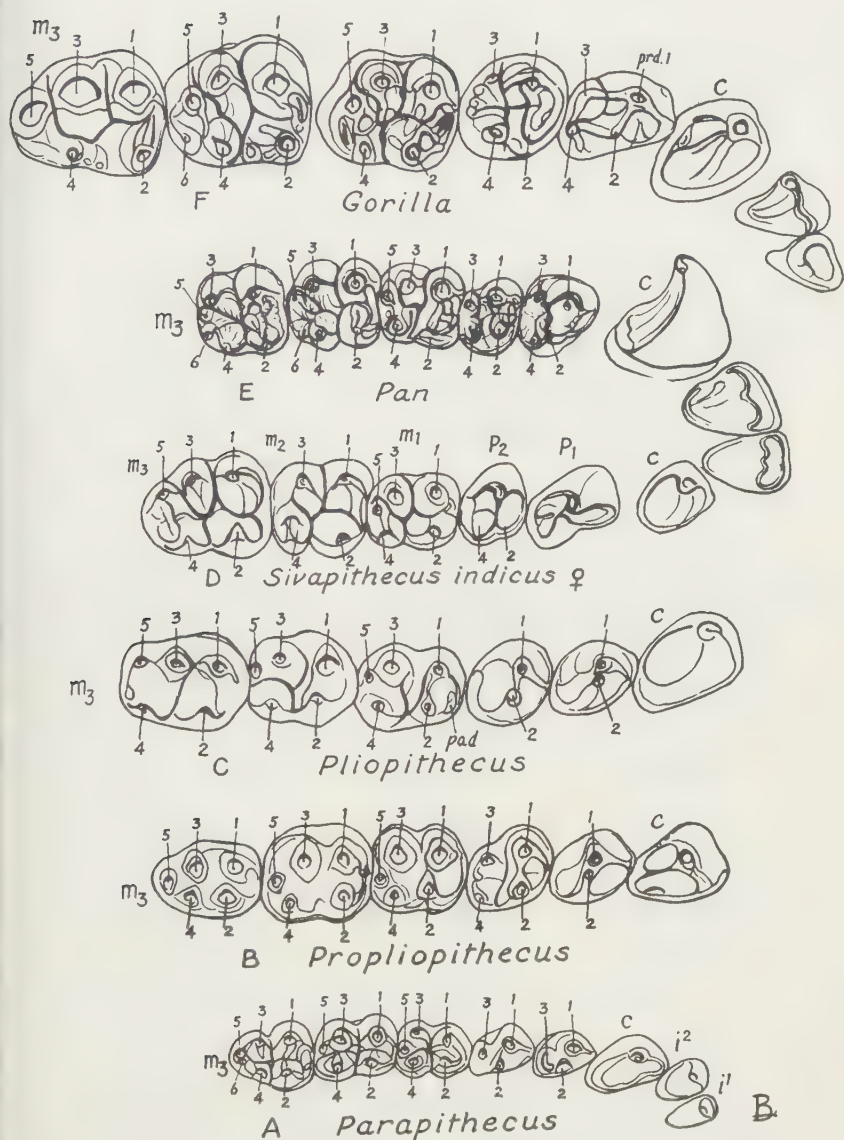
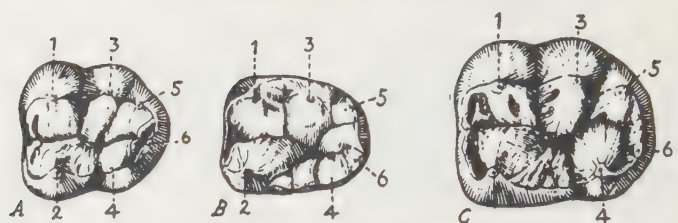
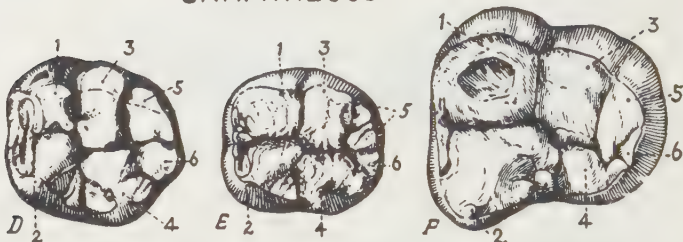


Fig. 10 Left lower teeth of fossil (A-C) and recent (E-F) anthropoid apes, showing location of principal cusps and grooves. After Gregory. Data from photographs (A-C), casts (A-C) and specimens (D-F). The typical "*Dryopithecus* pattern" is attained in D and somewhat modified in E, F. For abbreviations see figure 4.



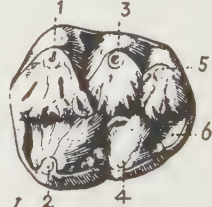
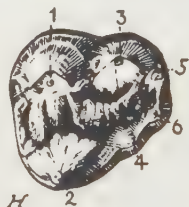
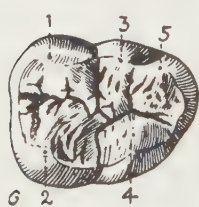
## SIVAPITHECUS



## PLESIANTHROPUS

## PARANTHROPUS

## GIGANTOPITHECUS

ORANG (*foss*)

## GORILLA

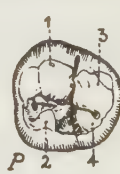
## GORILLA



## PITHECANTHROPUS

## SINANTHROPUS

## HEIDELBERG



## LE MOUSTIER

## AUSTRALIAN

## WEST AFRICAN

## WHITE

Hein Ziska del.

Fig. 11 Right lower third molars showing "Dryopithecus" pattern. From Gregory and Hellman. Based on specimens, casts and photographs. G-M after Weidenreich. For abbreviations see figure 4.



('38) have shown that in a presumably female *Sivapithecus* the upper canine crown is remarkably short, and that it seems to be approaching the premolars in the possession of an anterior vertical groove and a slight basal lingual swelling. Weidenreich ('37) also showed that the lower canine of the female *Sivapithecus* although very small was morphologically allied in crown-pattern to the lower canine of a certain female orang. The upper canines of Broom's type of *Paranthropus* are quite small in comparison with the molars. Thus indications are not lacking that as the upright posture was attained the dental arches were shortened and the canines reduced.

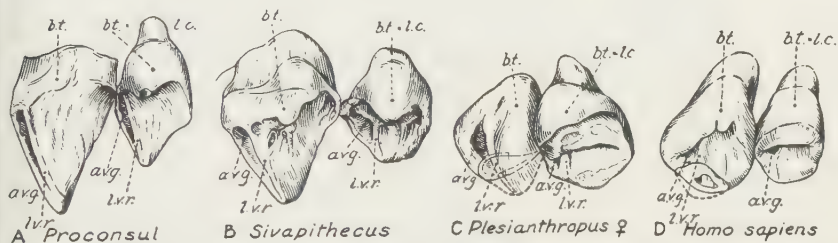


Fig. 12 Right upper canine and first premolar. Inner view. After Gregory and Hellman. A from cast, B-D from specimens. avg, anterior vertical groove; bt, basal tubercle; l.c., lingual cingulum; l.v.r., lingual vertical ridge.

The high pointed crown of the first lower premolar of the existing anthropoids contrasts with the low bicuspid human form of this crown in the Australopithecinae, *Sinanthropus* and *Homo*. Accordingly the irreversibilitarians hold that the bicuspid could not have been derived from the compressed conical crown and hence that man could not have been derived from any of the Dryopithecinae; but, as pointed out by Hellman and Gregory ('38) a comparative series of first lower premolar crowns indicates that the bicuspid crown of this tooth in man has apparently been derived partly by reducing the height of the protoconid and by a reduction of the transverse diameter across the post cuspidal fossa, although some of the originally oblique asymmetry of the crown is retained

in *Sinanthropus* and even in *Homo*. This case exemplifies what I regard as the anachronism of demanding that the remote ancestors of any line must already possess all the habitus features of its distant descendants.

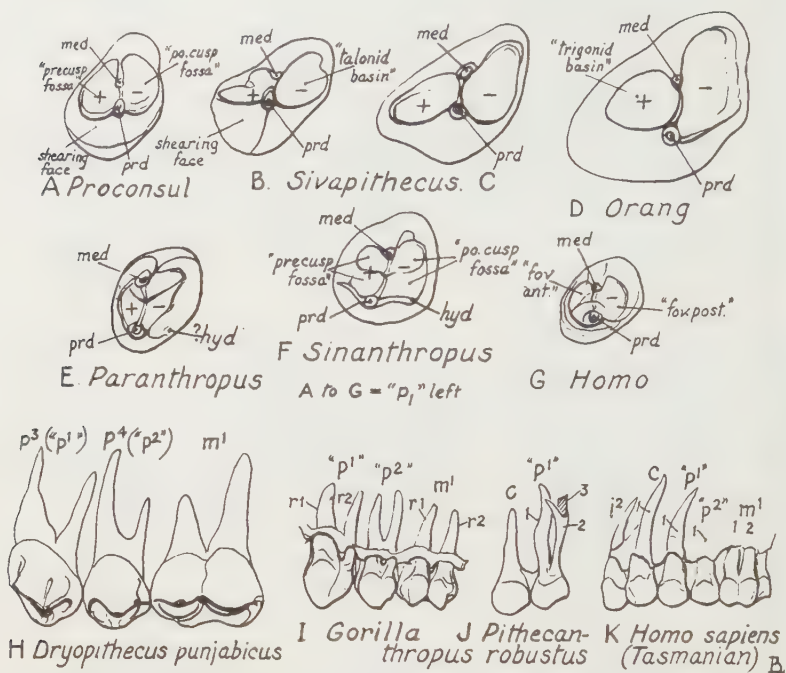


Fig. 13 Comparative morphology of the anterior lower premolar crowns and of the upper premolar roots.

#### CONCLUSIONS

The balance of present evidence suggests that evolution emerging seems long ago to have overcome most of the objections now posed for her by the irreversibilitarians. She seems indeed to be rather a pragmatist, with her eye on the motto: *solvitur ambulando*; nor does she hesitate to cast aside, erase or alter parts of her earlier plans, increasing this part or diminishing that; but always within the limits imposed by the varying incidence of hereditary factors and by changing selective pressures of successive environments.

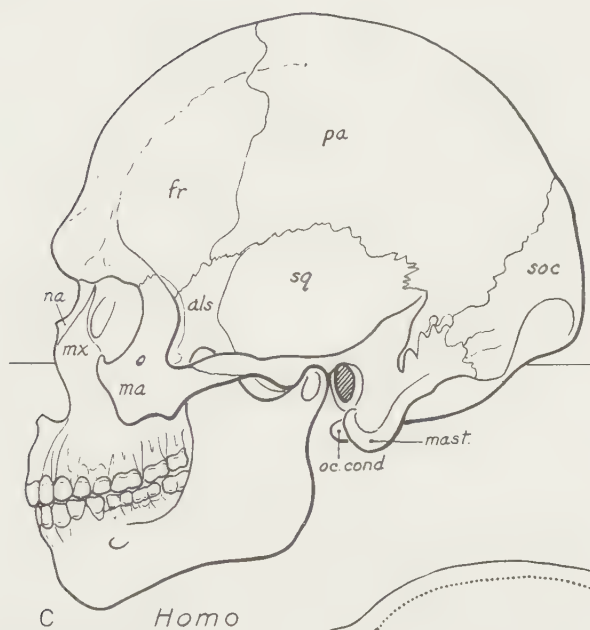
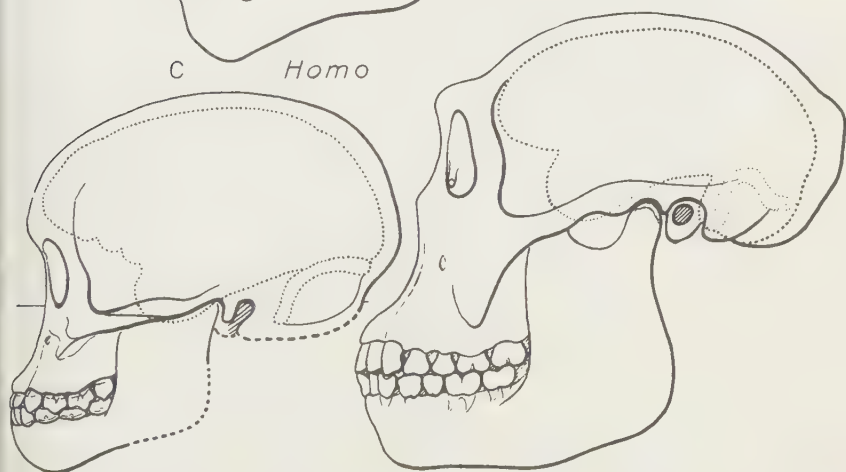
C *Homo*A *Australopithecus* juv.B *Plesianthropus* ♀

Fig. 14 A, outline of *Australopithecus* skull. After Dart. B, tentative restoration of *Plesianthropus* skull with inscribed brain cast. Data from Broom and Schepers. C, sketch of Tasmanian skull, with lower jaw adapted from other specimens. Dept. of Anthropology, Amer. Mus. Nat. Hist.

The Australopithecinae, whether they were direct ancestors of man or merely one of his great great uncles, have already contributed materially to this far-reaching definitive result: that man can now be securely linked with the anthropoid stock, not only by cumulative comparative morphological evidence, but also by good fossil evidence. Perhaps their greatest contribution is the fact that although standing on the very threshold of mankind, their brains were distinctly lower than those of *Homo sapiens*, who in turn was once regarded as being only a "little lower than the angels."

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IMMUNOLOGY AND EVOLUTION.— We may [attempt] to estimate what contributions may reasonably be expected in the future, as a result of the application of immunological methods to systematics, evolution and anthropology. We may anticipate, first, that the degree of relationship of various anthropoids to man will be estimated not only by the cross-reactions which their bloods exhibit with precipitating sera but also by the incidence of genes which are the same as, or similar to, the blood group genes found in human red cells. I believe we may anticipate with some confidence that the old concepts of human races, based on skin color, hair form, shape of skull, and so forth, will be eventually superseded by concepts based on the distribution of known genes, of which the blood group genes form the first example, although not, let us hope, the last. — William C. Boyd. *Systematics, evolution and anthropology in the light of immunology: Quart. Rev. Biol.*, vol. 24, no. 2, June, 1949, pp. 102-108.

## SOME NOTES ON THE GIGANTOPITHECUS QUESTION

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It was to Weidenreich's great credit that he published a detailed description (Weidenreich, '45, pp. 63-86) of three unusually large primate molars originating from Chinese drug stores, one of which had already been described by Von Koenigswald ('35) a decade earlier but which were unsatisfactorily known. In connection with the Chinese teeth, *Gigantopithecus blacki*, Weidenreich also described large but unquestionably hominid remains from the Javan Pleistocene (*Meganthropus palaeojavanicus*, and *Pithecanthropus robustus*).

Weidenreich, who in 1937 still spoke of *Gigantopithecus* as being a "giant orang" (Weidenreich, '37, p. 145), more recently regarded the big primate teeth as representing a typical hominid and not an anthropoid (as its name would imply), and defended the theory that this form should be placed at the root of the genealogical tree leading to *Pithecanthropus* and to its Chinese cousin *Sinanthropus*. Weidenreich ('45, p. 86) even stated that the hominid rather than anthropoid nature of the *Gigantopithecus* molars is a fact beyond possibility of objection, but in this he is not followed by other physical anthropologists like Hooton ('47, p. 421) and Le Gros Clark (private communication of June 9, 1948). The question as to whether *Gigantopithecus* is a hominid or an anthropoid cannot be settled definitely. What we need is the canine, or rather the P<sub>3</sub> to make a decision. Broom ('46, p. 66) thinks that an isolated canine from the Pleistocene Hoshangtung cave, Yunnan province, China, figured and discussed by Weidenreich

('37, p. 30-31, figs. 61 and 258) and referred by him to the orang-utan, belongs not improbably to *Gigantopithecus*. However, I have made this specimen the holotype of a gigantic fossil race of the orang-utan, *Pongo pygmaeus weidenreichi* (Hooijer, '48a, p. 280). It is a female lower C, of the right side, larger and less hypsodont than its homologue in the subfossil Sumatran orang-utan, *Pongo pygmaeus palaeosumatraensis* (Hooijer, '48a, p. 187), which, in turn, differs in the same ways from the female lower C in the recent orang-utan. The difference in size between *Pongo pygmaeus weidenreichi* and the geologically younger races is statistically significant.

It is not, however, my intention to criticize Weidenreich's paper as far as his exemplary descriptions are concerned but simply to give my views, as a vertebrate paleontologist on the phylogenetic speculations upon which Weidenreich felt himself justified in entering.

Weidenreich arrived at the conclusion that the *Gigantopithecus* molars combine gigantic size with characters more primitive than those of their homologues in the Javan *Meganthropus* and *Pithecanthropus robustus*, which, in turn, are larger and more generalized in character than *Pithecanthropus erectus* and *Sinanthropus*. The giant forms and *Pithecanthropus* are all taken as of Middle Pleistocene age (Weidenreich, '45, pp. 101, 105, and 112-113), which is regarded as a possible objection to the theory that these forms represent succeeding stages in a phylogenetic line. But, it is argued, the nature of the Trinil beds — a secondary, so-called lahar deposit — does not guarantee that their fauna is absolutely unified as to age: De Terra ('43) accepts the possibility of redeposition of material in the Trinil horizon during Late or even Post-Pleistocene times. Von Koenigswald ('36) had raised no objection to the idea that Lower Pleistocene (Djetis) fossils were secondarily deposited in the Middle Pleistocene Trinil bone beds. And the *Stegodon-Ailuropoda* fauna to which *Gigantopithecus* evidently belongs may be Lower Pleistocene in age (Weidenreich, '45, p. 113). Consequently *Gigantopith-*

*ecus* may be older than the Javan hominids, with the exception of the Modjokerto baby skull recorded by Von Koenigswald in 1936, the Lower Pleistocene age of which is not questioned but whose specific identity is still uncertain. If "*Homo modjokertensis*" is a *Pithecanthropus robustus* baby, one of the giants at least would be not only morphologically but also geologically the oldest.

Though it follows from the above digression that it has been accepted that the age of a fossil from the Trinil bone beds can range from Lower to Upper or even to Post-Pleistocene if this demanded for a special theory, it is perhaps not superfluous to state that not all the Javan ape-men besides "*Homo modjokertensis*" originate from the Middle Pleistocene beds. As is evident from Von Koenigswald's paper of 1940 ('40, p. 142; this paper had not yet reached the United States when Weidenreich wrote his 1945 paper) as well as from Von Koenigswald's letter to Weidenreich ('45, p. 16), the *Pithecanthropus* mandible B (too large for *Pithecanthropus erectus* and used in Weidenreich's reconstruction of the skull of *Pithecanthropus robustus* represented on pls. 4a, 4b, and 5a of Weidenreich, '45) and *Meganthropus palaeojavanicus* are both from the Lower Pleistocene (Djetis) beds. Thus the only thing we can state is that the *Pithecanthropus* of the Lower Pleistocene is larger than that of the Middle Pleistocene. And this is not surprising at all.

A similar maximum in size, which may or may not be followed by extinction, may be observed at the same time (Lower Pleistocene, Villafranchian) in many different groups of animals: the Duplicidentata, the Sciuroidea, the Perissodactyla, the Artiodactyla, and even in Mollusca: the Unionidae (Teilhard de Chardin and Pei, '41, p. 74). From the beginning of the Pleistocene there has been a widespread progressive diminution in size in many mammalian genera and families, both on continents and on islands. There are numerous examples showing that gigantism has not played a role in the evolution of the Hominoidea exclusively. Virtually all living species date back into the Pleistocene, and during my studies



on fossil and prehistoric mammals I have repeatedly found fossil and even subfossil remains referable to living species to be larger on the average than the corresponding recent material. For the sake of brevity I may refer to previous papers, mainly dealing with southeastern Asiatic mammals (Hooijer, '46a, pp. 29 and 54; '46b; '46c, p. 265; '47b, p. 288; '48a, pp. 279 and 292; '48b, p. 1322). It is therefore, just what we should expect if Pleistocene hominids show an excess in size over their recent representatives. The development of gigantism is neither a local nor an accidental event. But this does not mean that the giants are necessarily the ancestors of the later, smaller, forms.

*Gigantopithecus* belongs to the so-called *Stegodon-Ailuropoda* fauna, which is now known from Southern China, Indo-China, Upper Burma, and Java, and some members of which I have studied very carefully without finding a single piece of evidence that the (Lower or Middle) Pleistocene Chinese form is ancestral to that of Java.

There are two other "giants" in the Pleistocene Chinese fauna besides *Gigantopithecus* which have a representative in the Javan Pleistocene, viz., *Tapirus augustus* Matthew et Granger and *Pongo pygmaeus weidenreichi* Hooijer. *Tapirus augustus* cannot be placed in the ancestral line of *Tapirus indicus* Desmarest of the Javan Pleistocene because of its more molarized premolars (Hooijer, '47b), and *Pongo pygmaeus weidenreichi* cannot as yet be stated to have been ancestral to *Pongo pygmaeus palaeosumatrensis* and to *Pongo pygmaeus* subsp. from the Pleistocene of Java (Hooijer, '48a). These are results of studies on the whole dentition, while *Gigantopithecus* is represented only by three teeth!

The question as to whether *Meganthropus* (incidentally, not believed to be generically distinct from *Pithecanthropus* by Weidenreich, '45, p. 99) is really the forerunner of *Pithecanthropus robustus* can only be decided by the discovery of the calvarium of *Meganthropus* and of the mandible of *Pithecanthropus robustus*. The lower teeth in primates are typically more primitively built than the upper. However, it seems



beyond doubt that *Pithecanthropus erectus* and *Sinanthropus pekinensis* are only racially distinct, and this should be borne out by naming them *Pithecanthropus erectus erectus* (Dubois) and *Pithecanthropus erectus pekinensis* (Black) respectively. But as long as anthropologists have the habit of bestowing distinct generic names on teeth and jaw fragments as if these names mean nothing more than vernacular names (cf., Weidenreich, '43, p. 246), and also in cases where specific or sub-specific differentiation is in fact the most that can be recognized, there is little hope for a more zoologically correct hominid nomenclature to be generally accepted. Simpson ('45, p. 188) wisely suggests that it would be better for the zoological taxonomist to set the family Hominidae apart and to exclude its nomenclature and classification from his studies.

In concluding these remarks I would say that even if *Gigantopithecus* should be a hominid (which remains to be proven) there would be no parallel among the associated fauna of a case of a Pleistocene Chinese form being the direct ancestor of a corresponding Javan form; thus far there is actually only counter-evidence. The culmination in size of the Hominoidea in the Lower Pleistocene is paralleled by many other contemporaneous cases, which, we must confess, we are still at a loss to explain. The material at hand in the case of the ape-men is too scanty and in addition not even always directly comparable. In the present state of our knowledge it would seem that nothing is gained by leaving the sound base of morphology.

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## PRESENT STATUS OF RH BLOOD TYPES AND NOMENCLATURE

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The discovery by Landsteiner and Wiener ('40) of the Rh blood factors was of great significance both for clinical medicine and for anthropology. Studies of the Rh factor and its subtypes have revealed significant differences among different human populations and it seems probable that the Rh types will exceed the ABO or MN factors in anthropological usefulness. It also seems likely that some at least of the differences are due to the action of natural selection, acting on heterozygous infants who develop the disease called "erythroblastosis fetalis," but a consideration of this here would take us too far afield. As anthropologists, we are primarily interested in the racial differences. A summary of results on various racial groups will be published elsewhere (Boyd, '49). However, before workers who have not closely followed current developments in serology can make use of the new data, they must first of all understand the symbols in which they are expressed. This is unfortunately not quite as simple as one might like, partly due to the inherent complexity of the genetic situation, and partly due to the existence of two rival systems of nomenclature, neither of which has as yet won exclusive acceptance. It is the purpose of this paper to explain the genetic situation, as we know it at present, and the principle nomenclatures involved.

The first nomenclatures were devised by Wiener ('41). They were successively modified in the light of new results and in response to changes in Wiener's thinking about the subject. In the meantime the British (Race, '44) proposed an

alternative nomenclature which is widely used by them, and by some workers in this country. It seems simplest to begin with the British nomenclature, which at the present time is so widely used that anthropological workers can hardly ignore it and which is perhaps in some ways somewhat simpler (in other ways it proves more complex). Since it does not have priority, however, and since it was originally based on a theory of inheritance which is still unproven, it will be desirable to show how this nomenclature corresponds to the latest nomenclature of Wiener. A committee appointed by the National Institute of Health (Castle, Wintrobe and Snyder, '48) recommended that Rh blood typing sera be labeled with both nomenclatures and this is perforce done in the case of all sera offered for sale in interstate commerce. However, the anthropologist can hardly resist the hope that eventually one of the nomenclatures will be discarded. Strandkov ('48) has proposed a nomenclature which is a kind of hybrid of the two, but it does not appear that it has ingratiated itself with either school.

The British nomenclature was based on these assumptions: (1) there exist three adjacent and therefore closely linked loci on the chromosome which carries the Rh genes; (2) each of these genes determines the production of one of the Rh antigens. It was proposed that three pairs of genes would account for the situation. These pairs were designated C, c; D, d; E, e. Thus 6 different antigens should be produced and it was postulated that 6 different antisera would be found to react with them. At the time the prediction was made two of the antisera were still unknown, but they have since been found. Since each individual chromosome will possess three of the possible 6 Rh antigens, the possible chromosome combinations are 8 in number, as shown in table 1.

If three different gene loci were really involved in the inheritance of the Rh groups, crossing-over would be possible between them, as Wiener ('48), Rife ('48) and others have pointed out, and the 8 different chromosomes shown in table

1 should be in cross-over equilibrium<sup>1</sup> in any given population. This is in general not true, however, and consequently it would seem either that the three-locus theory is incorrect, or that the loci are so close together that crossing-over is extremely rare.

According to Wiener ('48), the Rh blood groups are inherited not by a series of linked loci but by a series of 8 allelomorphic genes all capable of occupying the same locus. According to Wiener's latest nomenclature, these genes, in

TABLE 1

*Possible chromosome types and reactions with anti-rhesus sera, according to the British nomenclature*

CHROMOSOME	REACTION WITH SERUM <sup>1</sup>					
	anti-C	anti-D	anti-E	anti-e	anti-d	anti-e
cde	—	—	—	+	+	+
Cde	+	—	—	—	+	+
cdE	—	—	+	+	+	—
CdE	+	—	+	—	+	—
cDe	—	+	—	+	—	+
CDe	+	+	—	—	—	+
cDE	—	+	+	+	—	—
CDE	+	+	+	—	—	—

<sup>1</sup> The symbol + indicates a positive reaction (agglutination); — indicates a negative reaction.

the order shown in table 1 are:  $r$ ,  $r'$ ,  $r''$ ,  $r^v$ ,  $R^0$ ,  $R^{0'}$ ,  $R^{0''}$ ,  $R^z$ . The gene  $R^{0'}$  produces two antigens (C and D) designated by Wiener as  $Rh'$  and  $r^0$ , and is thus a "double acting" gene. Wiener designates it  $R^1$  for short. Similarly  $R^{0''}$  (cDE) is designated as  $R^2$ . The combinations CDE and CdE were not recognized by Wiener originally, but were identified by other workers. Following their suggestions, Wiener now represents them by  $R^z$  and  $r^v$ . The gene  $R^z$  is very rare in people of European descent but relatively high (3 to 6%) in Asiatics, American Indians and Australian aborigines.

<sup>1</sup> That is, the various types of chromosomes should be equally frequent, allowing for differences in the frequencies in the population of the various Rh genes.



Originally only anti-sera reacting with genes which Wiener calls "Rh genes" were observed, but soon Levine ('41) and co-workers found a serum which systematically reacted with all the Rh-negative bloods. He called this an anti-Hr serum, obtaining the symbol by inverting the letters Rh. However, it was found that (a) more than one anti-Hr serum (see below) was possible and (b) such sera did not react solely with the Rh-negative bloods. The English workers do not use the symbol Hr, but Wiener and certain other American workers continue to do so.

TABLE 2

*Rh genes and their reactions with anti-Rh and anti-Hr antisera, according to Wiener's nomenclature*

GENE	REACTION WITH SERUM					
	anti-rh'	anti-Rh <sub>o</sub>	anti-rh''	anti-hr'	anti-Hr <sub>o</sub>	anti-hr''
r	—	—	—	+	+	+
r'	+	—	—	—	+	+
r''	—	—	+	+	+	—
r <sup>y</sup>	+	—	+	—	+	—
R <sup>o</sup>	—	+	—	+	—	+
R <sup>1</sup>	+	+	—	—	—	+
R <sup>2</sup>	—	+	+	+	—	—
R <sup>3</sup>	+	+	+	—	—	—

A table of the Rh-Hr genes and their reactions with the various antisera according to Wiener's nomenclature is shown in table 2.

According to Wiener's nomenclature the antisera designated by the British as anti-C, anti-D, and anti-E (table 1) are designated anti-rh', anti-Rh<sub>o</sub>, and anti-rh'' respectively, and the sera called by the British anti-c, anti-d, and anti-e are designated as anti-hr', anti-Hr<sub>o</sub>, and anti-hr''. The only blood which is correctly called completely Rh negative would react with none of the three anti-Rh sera, anti-C, anti-D, or anti-E, and, as can be seen from tables 1 and 2, would react with all three of the anti-hr sera. If we consider all 6 of the known sera, then, there is no blood which does not react with at least three of them.

TABLE 3

*The 36 possible Rh genotypes, showing the reaction of each with each of the 6 antisera<sup>1</sup>*

GENOTYPE	REACTION WITH SERUM					
	anti-C	anti-D	anti-E	anti-c	anti-d	anti-e
cde/cde	—	—	—	+	+	+
cde/Cde	+	—	—	+	+	+
cde/cdE	—	—	+	+	+	+
cde/CdE	+	—	+	+	+	+
ede/cDe	—	+	—	+	+	+
ede/CDe	+	+	—	+	+	+
ede/cDE	—	+	+	+	+	+
ede/CDE	+	+	+	+	+	+
Cde/Cde	+	—	—	—	+	+
Cde/cdE	+	—	+	+	+	+
Cde/CdE	+	—	+	—	+	+
Cde/cDe	+	+	—	+	+	+
Cde/CDe	+	+	—	—	+	+
Cde/cDE	+	+	+	+	+	+
Cde/CDE	+	+	+	—	+	+
cdE/cdE	—	—	+	+	+	—
cdE/CdE	+	—	+	+	+	—
cdE/cDe	—	+	+	+	+	+
cdE/CDe	+	+	+	+	+	+
cdE/cDE	—	+	+	+	+	—
cdE/CDE	+	+	+	+	+	—
CdE/CdE	+	—	+	—	+	—
CdE/cDe	+	+	+	+	+	+
CdE/CDe	+	+	+	—	+	+
CdE/cDE	+	+	+	+	+	—
CdE/CDE	+	+	+	—	+	—
cDe/cDe	—	+	—	+	—	+
cDe/CDe	+	+	—	+	—	+
cDe/cDE	—	+	+	+	—	+
cDe/CDE	+	+	+	+	—	+
CDE/CDe	+	+	—	—	—	+
CDE/cDE	+	+	+	+	—	+
CDE/CDE	+	+	+	—	—	+
eDE/cDE	—	+	+	+	—	—
eDE/CDE	+	+	+	+	—	—
CDE/CDE	+	+	+	—	—	—

<sup>1</sup> The symbols C, D, E, etc. are explained in the text. The symbol / is used to separate the two chromosome formulas (Fisher) = genes (Wiener). Note that genotypes CDE/cde, CDe/cdE, Cde/cDE, and CdE/cDe give identical serological reactions. Similarly, CDE/Cde, and CDe/CdE react the same, as do CDE/cDe and CDe/cDE. Cde/cdE and CdE/cde react the same, as do cDE/cde and cdE/cDe.

In the Rh series we have in effect 8 allelic genes, not counting more recently established alleles (see below). This means that 36 different genotypes<sup>2</sup> are possible, and they shown written out, together with their reactions with the 6 anti-sera, in table 3.

It will be noted that many genotypes can react with both of two alternative sera, such as anti-C and anti-c.

Table 3 is expressed in the British nomenclature, but the reader who has followed the above exposition should have no difficulty in translating it into Wiener's nomenclature, and thus obtaining a table (see table 4) similar to that presented by the latter (Wiener and Hyman, '48).

It will be seen from table 3, or the table of Wiener just referred to, that not all of the 36 possible genotypes are distinguishable, for some give identical reactions with all anti-sera. We may easily calculate the number of distinguishable genotypes. Considering each pair of antisera, such as anti-C and anti-c, we have three possibilities: + +, + —, and — + (since C and c are considered as alleles, and thus one or the other must be present, the possibility — — does not arise). Thus we have  $3 \times 3 \times 3 = 27$  possible different reactions with the 6 anti-sera, and 27 different genotypes can be distinguished serologically. Thus certain of the 36 genotypes are serologically indistinguishable, even if all 6 sera are available.

None but a very few workers have available more sera than anti-C, anti-c, anti-D, and anti-E, so that with each of the latter two sera only two possibilities arise, namely + and —. Therefore the use of these 4 sera enables only  $3 \times 2 \times 2$

<sup>2</sup> Each person has two chromosomes of each kind, and thus two genes out of any set of allelomorphs. If N genes are available to occupy a chromosome locus, the number of different genotypes possible will be equal to the number of terms in the expansion  $(r^1 + r^2 + r^3 + \dots + r^N)^2$ , where  $r^1$ ,  $r^2$ , etc., symbolize the various different allelic genes. The number of terms in such an expansion =  $\frac{n(n+1)}{2}$ . For example, for the ABO blood groups, this gives  $\frac{3(4)}{2} = 6$  which is correct. Since OA is indistinguishable from AA, and OB from BB, these 6 genotypes give the familiar 4 blood groups.

= 12 different genotypes to be distinguished at present. These are: CDe/C, CDe/c, CDE/C, CDE/c, cDE, cDe, Cde/C, Cde/c, CdE/C, CdE/c, cdE, and cde. Since we do not have anti-d serum available, the genotype CDe/C could include CDe/Cde,

TABLE 4

*The 27 Rh-Hr types and their 36 genotypes<sup>1</sup>*

DESIGNATIONS OF THE 8 RH TYPES	REACTIONS WITH RH SERUMS			DESIGNATIONS OF THE 27 RH-HR TYPES	REACTIONS WITH HR SERUMS			POSSIBLE GENOTYPES
	Anti-Rh <sub>0</sub>	Anti-rh'	Anti-rh''		Anti-Hh <sub>0</sub>	Anti-hr'	Anti-hr''	
rh	—	—	—	rh	+	+	+	r <sup>r</sup> r
rh'	—	+	—	r' <sup>r</sup> r'	+	—	+	r' <sup>r</sup> r'
				r'r	+	+	+	r'r
rh''	—	—	+	r''r''	+	+	—	r''r''
				r''r	+	+	+	r''r
rh'rh''	—	+	+	r <sub>y</sub> r <sub>y</sub>	+	—	—	r <sup>y</sup> r <sup>y</sup>
				r <sub>y</sub> r'	+	—	+	r <sup>y</sup> r'
				r <sub>y</sub> r''	+	+	—	r <sup>y</sup> r''
				r <sub>y</sub> r	+	+	+	r'r'' and r <sup>y</sup> r
Rh <sub>0</sub>	+	—	—	R <sub>0</sub> R <sub>0</sub>	—	+	+	R <sup>0</sup> R <sup>0</sup>
				R <sub>0</sub> r	+	+	+	R <sup>0</sup> r
Rh <sub>1</sub>	+	+	—	R <sub>1</sub> R <sub>1</sub>	—	—	+	R <sup>1</sup> R <sup>1</sup>
				R <sub>1</sub> R <sub>0</sub>	—	+	+	R <sup>1</sup> R <sup>0</sup>
				R <sub>1</sub> r'	+	—	+	R <sup>1</sup> r'
				R <sub>1</sub> r	+	+	+	R <sup>1</sup> r and R <sup>0</sup> r'
Rh <sub>2</sub>	+	—	+	R <sub>2</sub> R <sub>2</sub>	—	+	—	R <sup>2</sup> R <sup>2</sup>
				R <sub>2</sub> R <sub>0</sub>	—	+	+	R <sup>2</sup> R <sup>0</sup>
				R <sub>2</sub> r''	+	+	—	R <sup>2</sup> r''
				R <sub>2</sub> r	+	+	+	R <sup>2</sup> r and R <sup>0</sup> r''
Rh <sub>1</sub> Rh <sub>2</sub>	+	+	+	R <sub>2</sub> R <sub>2</sub>	—	—	—	R <sup>2</sup> R <sup>2</sup>
				R <sub>2</sub> R <sub>1</sub>	—	—	+	R <sup>2</sup> R <sup>1</sup>
				R <sub>2</sub> R <sub>2</sub>	—	+	—	R <sup>2</sup> R <sup>2</sup>
				R <sub>2</sub> R <sub>0</sub>	—	+	+	R <sup>1</sup> R <sup>2</sup> and R <sup>2</sup> R <sup>0</sup>
				R <sub>2</sub> r <sub>y</sub>	+	—	—	R <sup>2</sup> r <sup>y</sup>
				R <sub>2</sub> r'	+	—	+	R <sup>2</sup> r' and R <sup>1</sup> r <sup>y</sup>
				R <sub>2</sub> r''	+	+	—	R <sup>2</sup> r'' and R <sup>2</sup> r <sup>y</sup>
				R <sub>2</sub> r	+	+	+	R <sup>2</sup> r, R <sup>1</sup> r'', R <sup>2</sup> r', and R <sup>0</sup> r <sup>y</sup>

<sup>1</sup> Does not include the reactions of the rare serum anti-rh''' (anti-C<sup>w</sup>), or the rare "intermediate" Rh factors.

and CDe/Cde, and genotype CDE/cde could include genotypes Cde/cDE, Cde/cDE, Cde/cDE, and CdE/cde.<sup>3</sup> And so on. The practical value of the anti-c serum in anthropology lies in the fact that it enables CDe/cDE to be distinguished from CDE/CDe and CDE/Cde, etc., thus enabling the "Asiatic" gene R<sup>2</sup> (CDE) to be detected.

In general the genes R<sup>1</sup> (CDe) and R<sup>2</sup> (cDE) are the commonest, but in Africa the gene R<sup>0</sup> (cDe) is more common, and in populations of European descent r (cde) is fairly common, particularly in the Basques (Etcheverry, '45; Mourant, '47). The other genes are mostly rare, extremely so in certain populations. The important gradients in gene frequencies are those between  $r = 0.37$  in Europe and  $r = 0$  in Asia, and  $R^0 = 0.035$  in Europe and  $R^0 = 0.45$  in Africa. However, no reports on populations studied using the very rare reagents anti-d and anti-e have yet been published, so not all the possible genotypes have been identified in reports published up to the present time.

The British workers have published findings on other alleles at the CDE loci. One of these, C<sup>w</sup>, has been recognized by Wiener, but he considers that some of the others are really "intermediate" Rh genes which give reactions of intermediate strength with certain of the reagents. Reagents for these newer Rh genes are not likely soon to be generally available, so that it will be some time before any extensive studies on their incidence in various populations are reported.

Simple formulas for calculating the frequency of the Rh genes from determinations of phenotype frequencies in populations have been given by Wiener and Sonn ('46). A method of calculation by the method of "maximum likeli-

<sup>3</sup> Some workers write always the "most probable genotype" for any given set of reactions. Thus some would write CDe/cDE (or, R<sub>1</sub>R<sub>2</sub>) for the blood which gave positive serological reactions with anti-C, anti-D, anti-E, and anti-e. It is obvious that this involves some guess-work, and that such genotypes can not always be correct. Thus the e antigen, written in this case, might actually be missing, and the genotype might actually be CDE/cDE (Rh'Rh<sub>2</sub>). It seems better to the present author to write only what is actually found.



hood" which gives the best statistical fit has been described by Fisher ('46).

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NEW ANTHROPOLOGICAL JOURNAL FROM GERMANY.—The Ferdinand Enke Verlag, Stuttgart, announces a journal to be edited by Prof. E. Frhr. von Eickstedt, entitled "HOMO, Zeitschrift für die vergleichende Forschung am Menschen," and also described as "Internationale Zeitschrift für menschliche Biologie," and "Organ der Deutschen Gesellschaft für Anthropologie." The periodical aims to carry on the scientific tradition and international character of the earlier "Zeitschrift für Rassenkunde." Four issues are planned yearly. Dr. A. H. Schultz reports that the first number, which has just appeared, makes a good impression, and that the price is RM 30. a volume. Articles announced for early appearance are as follows:

- Backhausz-Nemeskeri-Vajda: Rh-Faktor-Untersuchungen in Ungarn  
 W. Bauermeister: Geographische und soziale Faktoren der Rassenbildung  
 F. Bose: Klangstile der Rassenmerkmale  
 F. Burgdörfer: Die unterschiedliche Fortpflanzung nach der deutschen Familienstatistik  
 G. Cihak: Ergebnisse der Ausdrucksforschung der Graphologie  
 E. Frhr. v. Eickstedt: Vom Wesen der Anthropologie  
 E. Frhr. v. Eickstedt: Das Hamitenproblem. West-östliche Parallelen und Lösungen  
 F. Falkenburger: Das Rassenproblem in Ägypten. Eine kranilogische Studie  
 D. E. I. Grasso: El Problema linguistico en los Origenes oceanicos de Parte de los indigenas americanos  
 W. C. O. Hill: A study of the skelton of a full term Veddah compared with that of other Races  
 F. Keiter: Lebensalter und Kulturgeschichte  
 F. Keiter: Psychotonus als anthropologisches Geschichtsphänomen  
 W. Mühlmann: Ethnische Aufstiegsassimilation und Rassenwandel  
 K. V. Müller: Bericht über die Begabtenuntersuchung Niedersachsens  
 P. Müller-Using: Zur Begriffsbestimmung der Jagd  
 W. Rauschenberger: Das philosophische Genie und seine Abstammung  
 F. O. Schoch: Die Fuss-sohlreflexe als phylogenetisch bedingte Greif- und Loslassreflexe  
 G. Schwidetzky: Die Grundlagen der biologischen Sprachforschung  
 I. Schwidetzky: Gross-stadt und Kleinstadt nach sozialanthropologischen Untersuchungen in Schlesien  
 I. Schwidetzky: Der Männerwall der Städte  
 I. Schwidetzky: Typensysteme  
 H. Weinert: Die neuen vor- und frühmenschlichen Fossilfunde in ihrer Bedeutung für die menschliche Stammesgeschichte

# THE ABO, MN AND RH BLOOD GROUPS OF THE BASQUE PEOPLE

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TWO FIGURES

Soon after the discovery of the Rh blood groups, and of their effect in causing haemolytic disease of the new-born, both Haldane ('42) and Wiener ('42) pointed out that all deaths affected children who were heterozygous for this factor or, as we should now say, who were of the genotype Dd. Thus, equal numbers of D and d genes are being destroyed and the result will be the dying out of whichever is the rarer of these two genes in any given population, unless there is some compensating effect as suggested by Wiener ('42) and by Fisher, Race and Taylor ('44).

In all populations so far tested which are of non-European origin, the d gene is rare and the populations correspondingly stable from the Rh point of view. In Western and Central Europe, however, and in countries peopled from Europe, all adequate samples taken from whole countries have shown about 16% of Rh negatives, that is to say, of people who are serologically D-negative and genetically dd. From this we can calculate that the frequency of the d gene is 40% and that of the D gene 60%. The Rh distribution in European populations thus appears to be an unstable one, and we may reasonably suppose that it originated from the mixing, not many thousands of years ago, of two stocks, one predominantly Rh-positive and the other predominantly Rh-negative. Even if it is assumed that there is a mechanism which compensates for the genetic instability, it is still possible, though

no longer essential, to suppose such a mixing of populations to have taken place.

The Rh-positive element is likely to have come from the east since most of the peoples of Asia are as far as is known very largely, and in some cases almost entirely, Rh-positive; and the other Rh genes which accompany D are of the right kind. The source of the hypothetical Rh negative stock was, until recently, entirely unknown, but investigations detailed below have given considerable support to the suggestion that it is to be identified with the ancestors of the present Basque people.

The Basques are the only people in Western Europe who speak a language that does not belong to the Indo-European family. Their skulls show certain marked differences from those of other modern Europeans, and in some respects resemble those of the late Paleolithic inhabitants of Europe. Rather similar features are shown by some of the modern inhabitants of Wales, Ireland, the Dordogne, Sardinia, Northern Portugal and North Africa (Fleure and Davies, '36; Morant, '29; Vallois, '46).

It is however their ABO blood groups which have hitherto been the principal physical evidence for the unique position of the Basques among the peoples of Europe. On the fringes of Europe, in Iceland, Scotland, Ireland, North Wales, Sardinia and the Western Caucasus, and among certain Berber tribes in North Africa, we find a high frequency of group O blood. As shown by Boyd and Boyd ('37) and Irizar (see Boyd and Boyd, '37) in Spain, and by Vallois ('44) in France, the Basques resemble these people in their high O frequency but they differ from them and from all other peoples of Europe so far examined in having a very low B frequency.

It is thus clear that the Basques, while they may be akin to the Celtic and other peoples of the fringes of Europe, have retained a racial purity which cannot be demonstrated on blood group evidence for any of the others.

## MATERIAL AND RESULTS

These lines of reasoning showed the likelihood that the Basques would prove to have a markedly different distribution of Rh genes from the other peoples of Western Europe, and there appeared to be a possibility that they might be the almost unmixed descendants of the hypothetical Rh-negative race. Arrangements were therefore made with Mr. V. Grifols of Barcelona that he should send us specimens of the blood of Basque persons from San Sebastian for Rh testing. Before any specimens were received, however, Dr. E. Potter's book ('47) on the Rh factor drew attention to the work of Etcheverry ('45), which had previously remained unknown to us and to most English-speaking workers on Rh, and which showed that persons in the Argentine of Basque origin included over 30% of Rh negatives (see Mourant, '47; quoted also in this journal, vol. 6 n.s., p. 24).

The first specimens ("preliminary series" in the tables) received from Mr. Grifols (kindly collected by Dr. Irizar in San Sebastian) gave a general confirmation to these findings, but in spite of careful selection based on personal names (which incorporate the names of several generations of ancestors), and in spite of a typical Basque ABO blood group distribution, this whole series of specimens showed only 25.8% of D-negatives.

It therefore seemed to be most important to collect a larger number of specimens under expert anthropological guidance. Through the kindness and very efficient organization of the Basque Delegations in London, Paris and Bayonne, arrangements were made for one of us (J. N. M. C.) to make one expedition to Paris and two expeditions to the Basque country in the extreme southwest of France. In these areas specimens were collected from over 400 Basques, some of them domiciled on the French side of the frontier but the majority of them refugees from beyond the Pyrenees. Through the personal assistance of Professor J. M. de Barandiaran we were assured of the racial purity and also, in many cases, of the family relationships of each person tested. After eliminating the



small number of persons who were believed to be of mixed race, and the few others who were blood relations of other persons tested, there remained 383 persons whose blood groups were available for statistical study. (This is the "main series" of the tables).

A full examination was made of the  $A_1A_2BO$ , MN and Rh groups of the main series of specimens and of the specimens collected by Dr. Irizar. Since the latter represent a popula-

TABLE 1  
*ABO groups, main series*

GROUP	NUMBER	FREQUENCY	
		Observed	Expected
O	196	.5117	.5144
A <sub>1</sub>	143	.3734	.3728
A <sub>2</sub>	24	.0627	.0605
B	16	.0418	.0387
A <sub>1</sub> B	4	.0104	.0114
A <sub>2</sub> B	0	.0000	.0022
Total	383	1.0000	1.0000

<i>Gene frequencies</i>	
O	.7172
A <sub>1</sub>	.2153
A <sub>2</sub>	.0410
B	.0265
Total	1.0000

tion differing substantially from the main series they are considered separately. Except where otherwise stated all the results quoted in this paper refer to the main series of specimens collected by us personally. We have already published a preliminary note on part of our results (Chalmers, Ikin and Mourant, '48).

The frequencies of the ABO groups are shown in tables 1 and 5. In calculating the gene frequencies the corrections of Bernstein (see Wiener, '45) were used. As was expected, a very low frequency of group B and of gene B was found.

This confirmed that we were dealing with a sample of the population comparable in "purity" to that dealt with by previous workers. The O frequency was rather less than found by Boyd and Boyd ('37) but since our sample is larger than the other samples combined, and since our subjects are drawn from a wide area, our figures are likely to be the most trustworthy yet obtained.

The  $A_1:A_2$  ratio is about the same as for most races of Europe. The MN frequencies (table 2) show a slight but not significant excess of N over the usual European figures. Boyd

TABLE 2  
*MN groups, main series*

GROUP	NUMBER	FREQUENCY	
		Observed	Expected
M	113	.2950	.2893
MN	186	.4856	.4971
N	84	.2193	.2136
Total	383	.9999	1.0000

<i>Gene frequencies</i>	
M	.5379
N	.4621
Total	1.0000

and Boyd ('37) found a greater excess of N in testing 91 Basques.

The most important part of our work consisted in the determination of the Rh groups (table 3). The total frequency of D-negatives in our main series was found to be 29.2%, which is distinctly lower than Etcheverry's ('47) latest figures of 35.6% and the figures of 35% obtained by Vaccaro ('48) for Basques in Chile. Guasch ('48), examining 44 Basques from Barcelona, has found 34.1% of Rh-negatives.

We cannot entirely rule out the possibility that these authors are dealing with slightly different stocks from that which we have tested, but it is also possible that their anti-D

sera were rather weak and gave a small proportion of false negatives. In particular they may have been counting persons with the rare D<sup>n</sup> gene as Rh-negative. We found one such among the persons whom we examined and included in our statistics as D-positive, and two more were found who could not be included in our statistics because of family relationships.

TABLE 3  
*Rh phenotypes, main series*

REACTIONS WITH ANTISERA					PRINCIPAL GENOTYPE	NUMBER	FREQUENCY	
Anti-C	D	E	c	e			Observed	Expected
+	+	—	—	+	CDe/CDe	53	.1384	.1521
+	+	—	+	+	CDe/cde	161	.4204	.4032
—	—	—	+	+	cde/cde	105	.2742	.2826
+	+	+	+	+	CDe/cDE	26	.0679	.0570
—	+	+	+	+	cDE/cde	29	.0757	.0758
+	—	—	+	+	Cde/cde	6	.0157	.0157
—	+	—	+	+	cDe/cde	2	.0052	.0053
—	—	+	+	+	cdE/cde	1	.0026	.0026
—	+	+	+	—	cDE/cDE	0	.0000	.0053
+	—	—	—	+	Cde/Cde	0	.0000	.0002
+	—	+	+	+	Cde/cdE	0	.0000	.0001
—	—	+	+	—	cdE/cdE	0	.0000	.0000
Totals						383	1.0001	.9999

*Rh chromosome frequencies*

cde	.5316
CDe	.3756
cDE	.0707
Cde	.0147
cDe	.0050
cdE	.0025
Total	1.0001

Some support is given to the suggestion of regional variations in the Rh composition of the Basque people by our finding of an Rh-negative frequency below the Basque average among specimens collected by Dr. Irizar in San Sebastian and by Dr. Moulinier's ('49) similar finding (see elsewhere in this issue) in his work on specimens collected in valleys

in the southwest of France, both series showing a typical Basque ABO distribution. On the other hand our results have been analysed for internal evidence of heterogeneity

TABLE 4

*Main series classified according to ABO, Rh and MN groups*

PHENOTYPES CLASSIFIED UNDER PRINCIPAL GENOTYPE		O	A <sub>1</sub>	A <sub>2</sub>	A <sub>1</sub> B	B
CDe/CDe	M	10	4	1	0	0
	MN	15	6	2	0	0
	N	8	6	1	0	0
CDe/cde	M	22	18	6	2	4
	MN	36	33	2	0	3
	N	14	13	2	2	4
cde/cde	M	19	11	2	0	1
	MN	28	20	4	0	1
	N	11	7	1	0	0
CDe/cDE	M	4	1	0	0	1
	MN	9	6	0	0	0
	N	0	3	1	0	0
cDE/cde	M	2	2	1	0	0
	MN	9	7	0	0	1
	N	3	2	1	0	1
Cde/cde	M	1	1	0	0	0
	MN	1	1	0	0	0
	N	1	1	0	0	0
cDe/cde	M	0	0	0	0	0
	MN	1	0	0	0	0
	N	0	1	0	0	0
cdE/cde	M	0	0	0	0	0
	MN	1	0	0	0	0
	N	0	0	0	0	0

(table 4). Such heterogeneity as was found, especially a tendency for heterozygous CDe/cde to preponderate among the A's and homozygous CDe/CDe and cde/cde among the O's was not of a kind which would arise from systematic

heterogeneity of the population sampled, and was presumably due to chance errors of sampling.

It is at any rate clear that in all the Basque people examined for the Rh factor, the Rh negative frequency is approximately twice that found among other European people and the frequency of the d gene is in the neighbourhood of 60% (55% on our own figures). It is particularly important in view of Haldane and Wiener's theory of selection that the

TABLE 5  
*ABO groups, preliminary series (San Sebastian)*

GROUP	NUMBER	FREQUENCY	
		Observed	Expected
O	44	.5432	.5427
A <sub>1</sub>	27	.3333	.3361
A <sub>2</sub>	6	.0741	.0717
B	3	.0370	.0374
A <sub>1</sub> B	1	.0123	.0096
A <sub>2</sub> B	0	.0000	.0024
Totals	81	.9999	.9999

*Gene frequencies*

O	.7367
A <sub>1</sub>	.1911
A <sub>2</sub>	.0472
B	.0250
Total	1.0000

gene frequency is over 50% among the Basques and under 50% elsewhere in Europe.

In calculating the gene (chromosome) frequencies we first calculate a rough value for cde from the frequency of cde/cde and then work out the frequency of cDe from that of the genotypes cDe/cde + cDe/cDe. The total frequency of the C gene is then calculated from the totals of the genotypes CC and Cc, and is equal to the sum of the chromosome frequencies CDe + Cde. The total frequency of E is worked out similarly and is equal to cDE + cdE. Using the value



already found for cDe, a corrected value for cde is found by difference and used to calculate Cde and cdE from the genotypes Cde/cde and cdE/cde respectively. The two remaining frequencies, CDe and cDE are then calculated by subtraction. One specimen of the phenotype which includes cD<sup>u</sup>E/cde was treated as being cDE/cde in these calculations. The results and the "expected" phenotype frequencies worked out from them are given in table 3.

These results demonstrate another feature almost as striking as the high d frequency, namely the very low E frequency,

TABLE 6  
*MN groups, preliminary series (San Sebastian)*

GROUP	NUMBER	FREQUENCY	
		Observed	Expected
M	28	.3457	.2885
MN	31	.3827	.4974
N	22	.2716	.2144
Total	81	1.0000	1.0003

<i>Gene frequencies</i>	
M	.5371
N	.4630
Total	1.0001

though this is not so important from the selection point of view. It is however, another important piece of evidence pointing to the smallness of any mixing of the Basques with other peoples.

It is furthermore certain that the C<sup>w</sup> gene, rare as it is in Western Europe generally, is even rarer among the Basques. We found no example of it at all but as the only available testing serum was rather weak and the blood specimens were a few days old when tested, it is possible that we missed a very few examples.

TABLE 7

*Rh phenotypes, preliminary series (San Sebastian)*

REACTIONS WITH ANTISERA					PRINCIPAL GENOTYPE	NUMBER	FREQUENCY	
Anti-C	D	E	c	e			Observed	Expected
+	+	—	—	+	CDe/CDe	15	.1852	.1968
+	+	—	+	+	CDe/cde	35	.4321	.4139
—	—	—	+	+	cde/cde	18	.2222	.2314
+	+	+	+	+	CDe/cDE	5	.0617	.0542
—	+	+	+	+	cDE/cde	4	.0494	.0484
+	—	—	+	+	Cde/cde	2	.0247	.0251
—	+	—	+	+	cDe/cde	1	.0123	.0126
—	—	+	+	+	cdE/cde	1	.0123	.0126
—	+	+	+	—	cDE/cDE	0	.0000	.0037
+	—	—	—	+	Cde/Cde	0	.0000	.0007
+	—	+	+	+	Cde/cdE	0	.0000	.0007
—	—	+	+	—	cdE/cdE	0	.0000	.0002
Totals						81	.9999	1.0003

*Chromosome frequencies*

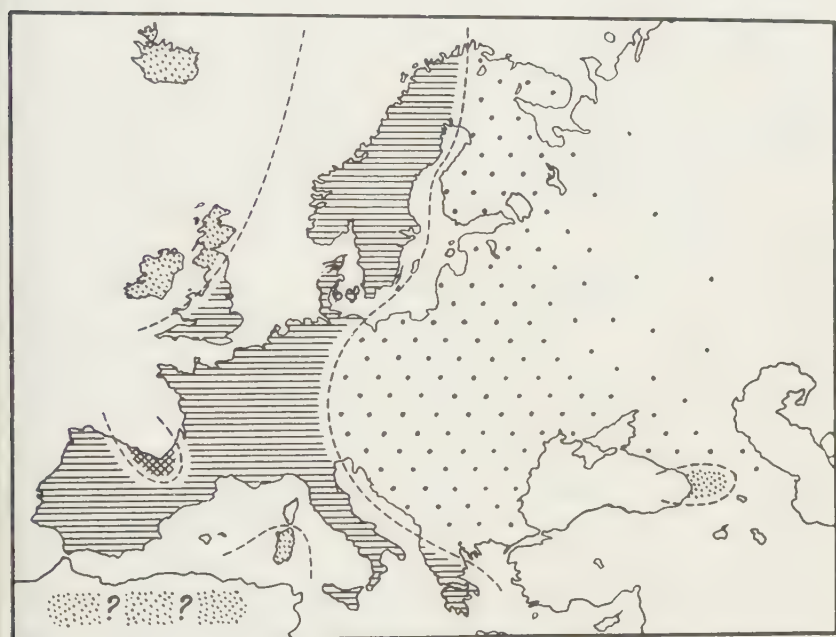
cde	.4810
CDe	.4183
cDE	.0486
Cde	.0261
cDe	.0129
cdE	.0131
Total	1.0000

## DISCUSSION

If we now assume that the present inhabitants of Europe are the result of the mixing of people akin to the present Basques with people of eastern origin, we can compare the hypothetical consequences of such a mixing with the actual results of observations by ourselves and others.

First, let us summarize the distribution of ABO groups in Europe, working from west to east (see fig. 1). As already stated, the Basques have a high O, moderate A, and very low B frequency. Then follow the peoples, largely Celtic speaking, with high O, moderate A, and B still low but several times higher than in the Basques. Next we find a belt occupy-

ing most of Western Europe, with high A and moderate O, with B and AB about the same as in the "Celts." Then, east of the Baltic-Elbe-Adriatic line, come the Slavonic peoples with A and O almost as in Western Europe, but with considerably highly B. We may probably regard these 4 classes







- |  |   |
|--|---|
|  <i>The Basques with high O, very low B and high Rh negative frequency.</i> |  <i>The main Western Europeans with high A.</i>            |
|  <i>The Celts and other peripheral peoples with high O.</i>                 |  <i>The Slavs and other Eastern Europeans with high B.</i> |

Fig. 1 The main divisions of the population of Europe distinguishable by means of blood groups.

of peoples as broadly representing 4 successive waves of invaders each pressing the previous arrivals towards the west.

While the picture is too complicated for us to enquire closely into the details of the mixing populations, it is clear

that in their high O and low B the Basques differ from the peoples of Western Europe in the opposite direction from the peoples of Eastern Europe, with high B and somewhat lowered O.

With regard to MN it is perhaps worth noting that the statistically insignificant rise of N in the Basques is matched by a significant rise of M in the peoples east of the Baltic, as compared with the general Western European norm.

In the case of the Rh groups a consideration of phenotypes yields a picture far too complicated for direct consideration. It is essential to consider rather the frequencies of the chromosomic combinations of Fisher's elementary genes, as shown in figure 2.

We then find that cde has a frequency of 53% among the Basques, 39% in England, a slightly lower frequency in Central and Eastern European countries and a much lower or even zero frequency throughout Asia and the rest of the world. CDe varies little as between the Basques and the rest of Europe. cDE is very much lower among the Basques than in England and shows a slight but definite rise eastwards in Europe. C<sup>w</sup>De behaves similarly to cDE but at much lower levels.

Thus we see that in nearly every respect in which the blood groups of the Basques differ from those of the other peoples of Western Europe, the tendency in Eastern Europe is in the opposite direction. Qualitatively therefore, we have a very good case for supposing the present population of Western Europe to have arisen from the mixing of a people akin to the Basques with peoples related to those now inhabiting Eastern Europe, though perhaps showing more extreme features than the modern Eastern Europeans.

Recent work (Prasad, Ikin and Mourant, '49; see fig. 2) on the blood groups of the people of India allows us to carry our speculations even further. It is well known that the eastward rise in B and M frequencies in Europe continues into Asia and in particular into India. It has now been shown that the trends observed in the frequencies of the various

Rh chromosomes are, on the whole, continued into India, as shown in figure 2. It can be said that if on the basis of Rh groups Western Europeans are to be regarded as the result of interbreeding of a people akin to the Basques with later immigrants, then the Indians show a nearer approach than any people so far studied to the Rh composition which we

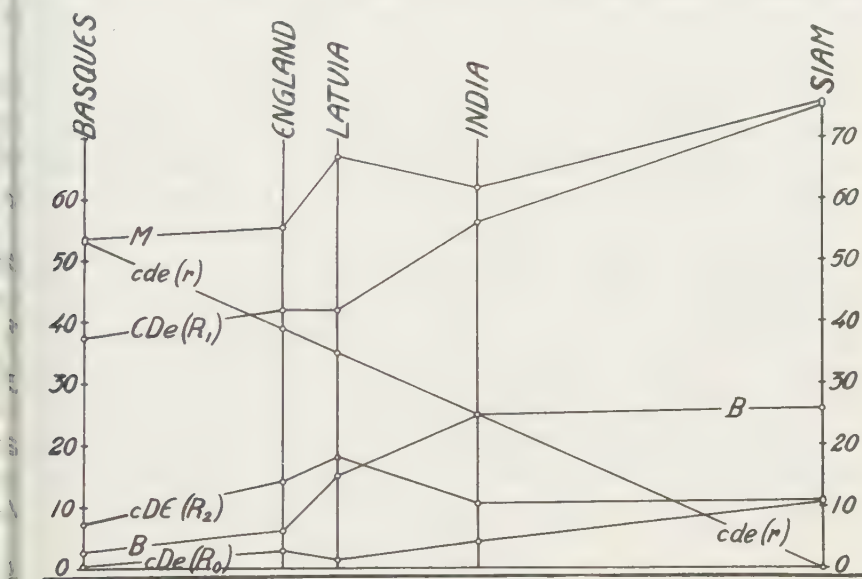


Fig. 2 Blood group gene frequencies (per cent) in Europe and Asia. Based on the present study and the work of Race, Mourant, Lawler and Sanger ('48); Race, Sanger, Lawler and Keetch ('48); Prasad, Donegani, Ikin and Mourant ('49); Phansomboon, Ikin and Mourant ('49).

The diagram shows the fall in frequency of the *cde* chromosome (and hence of Rh negative individuals) from west to east, and the corresponding frequency variations of the other common Rh chromosomes and the B and M genes. The spacing on the horizontal scale is arbitrarily arranged so as to make the frequencies of *cde* lie on a straight line.

should expect to find in such immigrants at a stage when they had only received a slight proto-Basque admixture. The chief discrepancy lies in the *cDE* frequencies, which are higher in Western Europeans than in either Basques or Indians. Since there appears to be a tendency for *cDE* to rise as we go northward in Europe it may be that a third element, coming



from the northeast, is involved or it may be merely that the main stream of invaders differed from modern Indians in having a higher cDE frequency.

Quantitatively, our data are not sufficient to identify individual primitive elements clearly and to show in what proportions they contribute to the present races. It is to be hoped however, that the future may yield data which will enable us to build up such a detailed picture and to separate the effects of those blood groups upon which natural selection has little effect (perhaps for example MN and P) from those (such as Rh and perhaps ABO) where selection as well as mixing has played a part.

One quantitative feature may however be mentioned. Fisher and Race ('46) have shown that a good case may be made for supposing the rare Rh gene combinations in England to have arisen by very rare crossovers from the common genotypes, e.g., Cde and cDe from CDe/cde. Race, Mourant, Lawler and Sanger ('48) have suggested the same hypothesis to account for the findings of Wiener, Zepeda, Sonn and Polivka ('45) in the Mexican Indians. Our figures for the Basques show the following chromosome frequencies:

Cde	.0147
cDe	.0050
cdE	.0025

Thus cDe does not, as it should on Fisher's hypothesis, equal the sum of Cde and cdE, but it is remarkable that the low frequency of the cDE/cde genotype is paralleled by the very low cdE frequency and the high CDe/cde by high Cde. Perhaps cDe is commoner than our statistics show, for we accidentally found, on family evidence, one person who appears in our statistics in the CDe/cde phenotype to be in reality CD<sup>e</sup>e/cDe.

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For collecting and sending to us the specimens which form our smaller series we should like to thank Mr. V. Grifols and Dr. Irizar. For rendering possible the collection of the

main series we wish to thank Professor J. M. de Barandiaran and the members of the Basque Delegations in London, Paris and Bayonne. One of us (J. N. M. C.) is in receipt of a Government Grant for Scientific investigation through the Royal Society, and a grant from the Salter Fund of St. George's Hospital Medical School.

## SUMMARY

The ABO, Rh and MN blood groups of about 500 Basques have been examined. Among 383 anthropologically selected individuals 29% of Rh-negatives (D-negatives) were found, nearly twice as many as are known in any population outside the Basque country and its periphery. Reasons are given for supposing that the present population of Western and Central Europe has arisen from the mixing of people akin to the modern Basques with later invaders from Asia.

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TEMPERATURE AND GROWTH.—The same semitropical lethargy which earlier engulfed the Mediterranean countries of Europe is today creeping northward over the United States and Central Europe. Later onset of the menses in girls and smaller adult stature in American college youth have replaced the trend of recent centuries toward earlier maturity and ever-better physique. In the Carolinas the reversal came with children born in 1918, at Cincinnati latitudes a little later, and in Wisconsin it still remains only an indefinite hint. It is especially significant that this physical downturn should have occurred at a time when the production and distribution of foodstuffs were at all-time peaks and when greatest emphasis was being laid on child care and nutrition. Children now have fewer illnesses and grow faster in their early years than ever before; yet the adult stature is showing evidence of decline.—Clarence A. Mills. *Temperature Dominance over Human Life*. *Science*, vol. 110, no. 2855, Sept. 16, 1949, pp. 267-271.

# THE RH FACTOR IN SOUTHWESTERN FRANCE. AN EXAMINATION OF THE BASQUE AND BÉARNAIS POPULATIONS

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Until recently no population was known with more than 16% of Rh negative persons. From 1946 onwards we carried out Rh tests on 1,200 specimens of blood taken from donors in the Bordeaux region and were surprised to find that 20% of them were Rh negative (the term Rh negative throughout this paper refers to negative reactions with anti-D serum). We then heard of the work of Etcheverry ('45, '47) who had found 35.6% of Rh negatives among 250 Basque emigrants in the Argentine. We then began, on the advice of Dr. A. E. Mourant, to direct our investigation particularly to the French Basque Country.

These investigations have covered more than 700 subjects but in our statistical analysis we have only retained 605 of them (516 Basques, 89 Béarnais) as giving a sufficient guarantee of racial purity. In this connection we traced the ancestry of each person as far back as possible for any evidence of racial heterogeneity. We were assisted in these studies by M. de Barandiaran, who is a specialist in Basque anthropology. For Basque material, we systematically took specimens from all over the three Basque provinces, and have thus been able to classify our results by cantons. For the serological tests we used anti-A, anti-B (with group O serum, anti-A + anti-B, as a further check), and anti-D.

Table 1 deals with the combined ABO and Rh groups of 516 persons of Basque origin, subdivided by province and





canton, and of 89 Béarnais from two regions. Table 2 gives the total percentage of Rh negative individuals for each of the three Basque provinces.

*Basques.* The ABO frequencies in total percentage (O, 57.9; A, 38.4; B, 2.7; AB, 1.0) agree well with previous published figures for the Basques. The overall percentage of Rh negatives is 24.42%, and the variations of Rh negatives within the different ABO groups are not statistically significant.

This percentage of Rh negatives is much lower than that of 35.6 found by Etcheverry, and considerably lower than that of 29.2 found by Chalmers, Ikin and Mourant (see elsewhere in this issue) for 383 Basques. It is however of the

TABLE 2

*Percentage of Rh negatives by Basque provinces*

PROVINCE	NUMBER TESTED	PERCENTAGE OF RH NEGATIVES
Labourd	68	22.05
Navarre	233	28.70
Soule	215	20.47

same order as the percentage of 25.8 Rh negatives found by the last named workers among 81 Basques from San Sebastian. This suggests that there may be important regional variations in Rh negative frequency among the Basques taken as a whole, which is borne out by the present figures when these are classified under provinces (see table 2). The difference between Navarre and Soule is statistically significant.

*Béarnais.* The distribution of the ABO and Rh groups among 89 Béarnais is also shown in table 1. Here the total ABO percentages (O, 51.8; A, 41.7; B, 6.5; AB, 0) correspond with figures for the rest of France rather than with the Basques. On the other hand, the Rh negative percentage of 35.25 is higher than anything yet published for any people other than the Basques and approaches the highest published Basque figure. One might plausibly explain this fact by the

presence of an important Basque element in this population living within the confines of the Basque country. Against this explanation we have the general lack of accordance between the ABO frequencies in the two populations and the fact that in our Béarnais sample the Rh negative frequency is actually considerably higher than in their immediate Basque neighbors. The total number of Béarnais so far investigated is, however, so small that conclusions can only be tentative and serve to point the way for more detailed studies of the serological anthropology of the people of France.

It is nevertheless already clear that there is a steady rise in Rh negative frequencies as one moves towards the south-west of France and the Basque country: Paris, 16%; Bordeaux region, 20%; Basque country, 24.4% to 35.6%. The relationship of such figures to those for the rest of Europe and Asia and their interpretation are discussed by Chalmers, Ikin and Mourant ('49).

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In conclusion, I should like to thank the following: Dr. A. E. Mourant for his helpful advice, for supplying anti-D serum and for translating this paper; Col. Julliard and Messrs. Bonnel and Robert of the S.C.T.R.A. at Percy, who supplied us with anti-A, anti-B, and anti-A + anti-B sera; the Prefet of Basses-Pyrénées and the Chief Medical Officer of the Place de Pau who helped us to obtain samples of blood; Miss Dabadie, social assistant at the Dispensary at Hasparren, and many others who assisted our investigations in the field and the laboratory.

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# THE RH BLOOD GROUPS OF THE POPULATION OF BAGHDAD

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The present paper is a record of the Rh blood groups of 300 inhabitants of Baghdad. The persons tested are believed to be a representative sample of the mixed Arab population of the city. The blood samples were tested with each of the 4 sera, anti-C, anti-D, anti-E and anti-c. The anti-C serum had the specificity anti-C + anti C<sup>w</sup>. All the sera were kindly supplied by Dr. A. E. Mourant of the Blood Group Reference Laboratory, London, and the technique of testing was that which I had learned in this laboratory and which is recommended in the Memorandum of the Medical Research Council (Mollison, Mourant and Race, '48).

The results of the tests are given in table 1. The chromosome frequencies (table 2) and the expected phenotype frequencies derived from them (table 1) have been calculated by Dr. Mourant.

A comparison with published chromosome frequencies for some European and Asiatic populations (table 3) shows a general fall in the frequency of cde from west to east, with a rise in CDe. Mourant (private communication) states that work now in progress shows that this trend is confirmed as regards India and is even more marked in Siam. A detailed reconsideration of the significance of the Baghdad figures must await studies of the Rh groups of the populations of other countries in Southwest Asia and the neighboring parts of Europe and Africa.

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I should like to thank Dr. A. E. Mourant for all the help which he has given me in the preparation of this paper.

TABLE 1

*Rh phenotype frequencies in the population of Baghdad expressed as percentages*

REACTIONS OF PHENOTYPE WITH ANTISERA				PRINCIPAL GENOTYPE IN PHENOTYPE	NUMBER	FREQUENCY OBSERVED	FREQUENCY EXPECTED (Calculated from table 2)
C	Anti- D	E	c				
+	+	—	+	CDe/cde	79	26.33	33.85
+	+	—	—	CDe/CDe	72	24.00	20.68
+	+	+	+	CDe/cDE	47	15.67	14.83
—	+	+	+	cDE/cde	41	13.67	14.55
—	—	—	+	cde/cde	31	10.33	8.06
—	+	—	+	cDe/cde	25	8.33	6.50
+	—	—	+	Cde/cde	3	1.00	0.88
—	—	+	+	cdE/cde	2	0.67	0.59
+	—	—	—	Cde/Cde	0	0.00	0.02
+	—	+	+	Cde/cdE	0	0.00	0.03
					300	100.00	99.99

TABLE 2

*Rh chromosome frequencies in the population of Baghdad expressed as percentages*

CDe	43.946
cde	27.107
cDE	15.313
cDe	11.059
Cde	1.554
cdE	1.021
100.000	

TABLE 3

*Rh chromosome frequencies*  
(Expressed as percentages to the nearest whole number)

	BASQUES <sup>1</sup>	ENGLAND <sup>2</sup>	LATVIA <sup>3</sup>	BAGHDAD	INDIA <sup>4</sup>
CDe <sup>5</sup>	34	42	43	44	56
cDE	7	14	17	15	6
cde	57	39	37	27	27
cDe	1	3	1	11	3
Cde	2	1	2	2	4
cdE	0	1	1	1	0

<sup>1</sup> Chalmers, Ikin and Mourant, '48.<sup>2</sup> Race, Mourant, Lawler and Sanger, '48.<sup>3</sup> Race, Sanger, Lawler and Keetch, '48.<sup>4</sup> Wiener, Sonn and Belkin, '45.<sup>5</sup> Includes C<sup>w</sup>De.

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**RH INCOMPATIBILITY AND ABORTION.**—In previous discussions of the possible relation of Rh incompatibility to miscarriage and abortion, the question does not appear to have been clearly posed. For statistical assurance, it is necessary to put it in the following terms: Is there any significant difference between the frequency of abortion and miscarriage in Rh-negative women, known to be actually sensitized, and for those particular pregnancies in which the fetus is Rh positive, and the frequency of abortion and miscarriage in other women?

When the problem is framed in these terms it becomes clear that studies of the total frequency of abortion and miscarriage in all Rh-negative women, as compared with Rh-positive women, serve to obscure rather than to clarify the issue. In the first place, fetuses that are Rh negative themselves, in an Rh-negative mother, would not be expected to abort by reason of Rh incompatibility, irrespective of whether or not the mother is sensitized. Such cases represent 22.7% of the pregnancies of Rh-negative women married to Rh-positive men (Rh-positive heterozygotes = 55.4% of all Rh-positive individuals, and one-half of the children of such unions would be Rh negative). Since about 28% of the pregnancies of Rh-negative sensitized women are therefore not pertinent to the point at issue, a considerable number of such pregnancies must be studied to render any but a large



differential statistically significant. In other words, unless very large numbers of cases are studied, the absence of any apparent difference in abortion frequency between Rh-negative sensitized women and their controls is likely to be due to the inclusion of Rh-negative offspring among the offspring of the Rh-negative sensitized women, rather than to the absence of any real difference. On the other hand, any differential that can be found and established statistically is really far larger than would appear at first sight unless this bias has been allowed for.

Division of the individual subjects into three groups, the Rh positive, the Rh negative nonsensitized, and the Rh negative sensitized, is no less important to a clear analysis. . . .

The data used in the investigation consisted of the obstetric histories taken by regular workers at the Baltimore Rh laboratory. . . .

The ratio of total reported abortions and miscarriages to pregnancies was 701/5,168, or 13.56%, for the 2,500 Rh-positive women; 297/2,247, or 13.2% for the 1,155 Rh-negative nonsensitized women; and 89/583, or 15.25%, for the 209 sensitized women. The total Rh-negative group, with 386/2,830 abortions, or 13.62%, is obviously not different from the Rh-positive group. The difference between the Rh-positive and the Rh-negative sensitized women is also without significance ( $\chi^2 = 1.3$ ;  $P = 0.30-0.20$ ). Bentley Glass. The relation of Rh incompatibility to abortion. *Am. J. Obstet. and Gynec.*, vol. 57, no. 2, pp. 323-332, February, 1949.

## THE RH AND MNS BLOOD GROUPS OF SOME STUDENTS FROM INDIA

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Our principal object in undertaking the work described in this paper was to gain some idea of the frequencies of the Rh blood groups in the population of India, since the results of previous studies differed widely from one another. It was clear from the known very great heterogeneity of the peoples of India and from the widely varying frequencies of the ABO groups that no single sample could give anything like a full picture of the Indian Rh situation, but in view of the discrepancies between previous results we felt that almost any sample known to represent pure Indians (i.e., without European admixture) would, if the bloods were tested in a fresh condition with sera of well-established specificity, be a material contribution to knowledge and a guide to future work. It was therefore decided to test approximately 100 students living in London and drawn as far as possible from all parts of India. We tested 31 persons from Bengal, 30 from Bihar, 10 from Bombay and smaller numbers from several other provinces.

The specimens were tested with the anti-Rh sera anti-C, -D, -E, -c; and those which were positive with anti-E were also tested with anti-e. The anti-C serum had the specificity anti-C + anti-C<sup>w</sup>. All C<sup>w</sup> positives are thus classified as C positive.

Experience has shown that in various populations a certain proportion of those bloods which are negative with most anti-D sera contain the D<sup>w</sup> antigen (Stratton, '46). All but one of the D-negatives (genotypes cde/cde and Cde/cde) were

therefore tested for this antigen by carrying out an indirect Coombs test with a strong "incomplete" anti-D serum. All the results were negative, showing the D<sup>u</sup> antigen to be absent in these specimens and presumably rare or absent in the population as a whole. All specimens were also tested with anti-A, anti-A<sub>1</sub> where relevant, anti-B, anti-M and anti-N. It appeared unlikely that by testing only 100 persons we should make a material addition to the existing body of determinations of ABO and MN groups of Indians. Our object was rather to define in terms of blood groups the relation between the population which we were testing and Indian populations previously tested. We were, however, able to supplement our MN observations by determining the S group (Race, Sanger, Walsh and Montgomery, '48) of most of the persons tested.

While we were aware that we were dealing with a heterogeneous population we could, in calculating gene frequencies, not avoid treating the problem as though it involved a homogeneous population. Such a treatment yields gene frequencies differing somewhat from the true values but lying within the range of values which characterize the separate homogeneous populations involved. It is, moreover, not impossible that in the populations sampled, as in Western and Central Europe, there is something like homogeneity with regard to the Rh groups despite considerable heterogeneity for ABO. Rh serological results are in any case so complex that it is very difficult to appreciate them except in terms of chromosome frequencies. We have in general used the methods described by some of us (Chalmers, Ikin and Mourant, '49) as being used in similar calculations on the blood groups of the Basques. In the case of the Indian population, however, the frequencies of  $cDe(R_0)$  and  $cde(r)$  are such that any method is liable to considerable error. We therefore calculated the total frequency of  $cDe + cde$  as for the Basques. This total is likely to be substantially accurate. We then calculated the approximate separate frequencies of  $cDe$  and  $cde$  from those of the phenotypes  $cDe/cde + cDe/cDe$  and  $cde/cde$  and then

divided up the above-mentioned total in the same proportions. The laborious maximum likelihood calculations (Fisher, '46) would yield somewhat better values for all the Rh chromosomes but would not be worth carrying out on such a small sample.

In the MN system we used the formulae

$$\text{gene M} = M + \frac{1}{2} MN$$

$$\text{gene N} = N + \frac{1}{2} MN$$

The ratio, MS chromosomes:total M genes, was calculated by square root methods from the ratio of the phenotypes MS:total M. The frequency of chromosome NS was calculated similarly.

### RESULTS

The detailed results of our MNS and Rh tests are shown in tables 1, 2 and 3. In the ABO system we found the following total numbers of individuals belonging to the different groups: O, 38; A<sub>1</sub>, 19; A<sub>2</sub>, 2; B, 37; A<sub>1</sub>B, 7; A<sub>2</sub>B, 2. The gene frequencies calculated from these observations agree almost

TABLE 1  
*The MNS groups of 95 students*

PHENOTYPE	NUMBER	FREQUENCY	
		Observed	Expected
MS +	27	.2842	.2627
MS -	10	.1052	.0973
MNS +	24	.2526	.2679
MNS -	16	.1684	.2120
NS +	5	.0526	.0445
NS -	13	.1368	.1155
	95	.9998	.9999
<i>Chromosome frequencies</i>			
	MS	.2881	
	M <sub>s</sub>	.3119	
	NS	.0601	
	N <sub>s</sub>	.3399	
		1.0000	

exactly with those found by Wiener, Sonn and Belkin ('45) who examined 156 men of the Indian Navy (all Moslems). Since our Rh and MN gene frequencies also agree very closely with those found by these workers it appears probable that

TABLE 2

*The Rh phenotypes of 105 students from India*

REACTIONS WITH ANTISERA					PRINCIPAL GENOTYPE	NUMBER OF INDIVIDUALS	PERCENTAGE FREQUENCY	
Anti-C	D	E	c	e			Observed	Calculated
+	+	—	—	+	CDe/CDe	37	35.24	36.43
+	+	—	+	+	CDe/cde	34	32.38	33.22
—	—	—	+	+	cde/cde	8	7.62	6.13
+	+	+	+	+	CDe/cDE	17	16.19	12.67
—	+	+	+	+	cDE/cde	3	2.86	6.09
+	—	—	+	+	Cde/cde	2	1.90	1.90
—	+	—	+	+	cDe/cde	3	2.86	2.30
—	+	+	+	—	cDE/cDE	1	0.95	1.10
+	—	—	—	+	Cde/Cde	0	0.00	0.15
						105	100.00	99.99

TABLE 3

*The Rh chromosome frequencies of Indian students expressed as percentages*

Cde	56.64
cDE	10.48
cde	24.77
cDe	4.27
Cde	3.85
<hr/>	
	100.01

both sets of results are reliable average figures for a considerable part of India.

Our results show a frequency for D-negatives of 9.5%: this result is compared in table 4 with those obtained by other workers and it will be seen that this frequency varies from 2% to 10%. These variations suggest that different workers



were sampling markedly different populations, though the possibility of technical errors in some of the work must also be considered.

Our Rh results as a whole show a close relation to those for Europe. They are certainly nearer to those for Europe than are those for any other non-European population yet tested and it is especially noteworthy that the respective chromosome frequencies for Western and Central Europe lie very near the means of the corresponding frequencies for

TABLE 4

*Percentage frequencies of D negative individuals found among Indians by different workers*

AUTHORITY	NUMBER TESTED	ORIGIN	PERCENTAGE OF D NEGATIVE PERSONS
Greval and Roy Chowdhury ('43)	200	Calcutta	10
Khanolkar and Sanghvi ('45)	100	Bombay	2
Wiener, Sonn and Belkin ('45)	156	Moslem sailors	9.7
Ranganathan Ramechandra Rao and Ratnakannan ('46)	145	Madras City	4.1
Greval and Roy Chowdhury ('46)	—	Calcutta	7.85
Present study	105	London students	9.52

Basques and for Indians. This aspect of the subject is treated more fully in a paper on the blood groups of the Basques (Chalmers, Ikin and Mourant, '49).

In agreement with Wiener, Sonn and Belkin we find the frequency of the M gene to be higher than the almost constant figures found for Europe, Africa and Eastern Asia but our value is much lower than that found for Indians by Greval, Chandra and Woodhead ('39). The frequencies found for the M and N genes are as follows:

AUTHORITY	NUMBER TESTED	M	N
Present study	105	61.9	38.1
Greval et al. ('39)	300	76.0	24.0
Wiener et al. ('45)	156	62.2	37.8

It is of interest that work on the Siamese (Phansomboon, Ikin and Mourant, '49, elsewhere in this issue) gives a higher M frequency than we have found for Indians though not as high as Greval's figure.

We think that our results show that important ethnographical results would be obtained from full blood group studies of groups of Indians carefully selected to represent the main elements of population which have been recognized by means of the older methods of physical anthropology, and from similar studies of the people of neighbouring countries. Reliable information regarding the distribution of the D and d genes and antigens would also be of great practical value to the numerous workers who are at present organizing transfusion services in the Far East.

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# ABO BLOOD GROUPS FROM PALAMAU, BIHAR, INDIA

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During the years 1946 and 1947 blood grouping investigations were carried out among the various aborigines of the district of Palamau, Bihar, India, under the auspices of the Bose Research Institute, Calcutta. It was necessary to confine the investigations to the southwestern portion of the district within the forest ranges of Chipadohar, Lat and Garu.

In Palamau the aborigines are fast being acculturated. The Oraons here are not like those of Ranchi district. Most of the aborigines are employed in the forest by the timber merchants and as such many of them have to shake off their tribal culture and lead a life peculiar to their present circumstances. This has affected the population growth. There is always a shortage of labor. Large families are scarce and miscegenation is high. This will be evident from the following discussion on blood groups.

The blood group data of the different tribes of the district are shown in table 1.

## DISCUSSION

Among the first 6 tribes shown in table 1 the Asuras, the Bhuiyas and the Cheros have a high frequency of group A while the Birjias, the Kharwars and the Kisans stand in sharp contrast to the former in having a very high frequency of B. It is difficult to generalize from such small samples but it can safely be said that in Palamau the two genes tended to be associated with two different groups of peoples. The Asuras and the Cheros undoubtedly form a very old ethnic strain and

the A gene was evidently more frequent among them. The Asura data are interesting in having B represented only by one AB individual in a small sample of 21. The Asuras (having a total population in 1941 of 2,024) are widely scattered in the district and at places they have disguised themselves as Lohars (blacksmiths), so that it is difficult to collect a good sample. The same is the case with the nomadic Birhors, who could not be contacted at all in the course of the last two tours.

The Kharwar and the Birjia (total population in 1941: 1,550) samples are interesting in having very low O and a

TABLE 1  
*Blood groups of selected tribes from Palamau*

TRIBES	O	A	B	AB	TOTAL
Asuras	8	12	0	1	21
%	38.10	57.14	0	4.76	
Birjias	5	13	22	5	45
%	11.11	28.89	48.89	11.11	
Bhuiyas	9	12	9	5	35
%	25.71	34.29	25.71	14.29	
Cheros	12	12	8	3	35
%	34.29	34.29	22.86	8.57	
Kharwars	9	11	22	11	53
%	16.98	20.75	41.50	20.75	
Kisans	11	4	13	2	30
%	36.67	13.33	43.33	6.67	
Korwas	22	31	37	24	114
%	19.30	27.19	32.46	21.05	
Oraons	30	32	39	14	115
%	26.09	27.83	33.91	12.17	

correspondingly high AB. The Kharwars show the second highest percentage of AB (20.75%), the highest being found among the Korwas (21.05%).<sup>1</sup> The Birjia blood groups were mostly collected from the few villages around Maromar, and the high amount of B may be influenced by inbreeding

*Korwa blood groups.* Indications of miscegenation are seen in a comparison of two Korwa samples. Majumdar ('43)

<sup>1</sup> Tennant (Gates, '36) found 24.1% of AB among the Tibetans, which is ascribed to Chinese intermixture.

has published a blood group study of the Korwas. Majumdar did not mention the actual place in Palamau district where he collected the Korwa bloods. The Korwa materials of the present paper were collected from the villages of Lat, Bere, Tanwai, Saidup, and Chipadohar, of which the first three places are on the border of Surguja State. The unity of the Korwa country, however, safely allows comparison of the present data with those of Majumdar.

The two sets of data are as follows:

	O	A	B	AB	p	q	r	D/σ	INVESTIGATOR
Korwas									
(114)	19.30	27.19	32.46	21.05	.233	.280	.439	2.1	Sarkar
Korwas									
(147)	31.7	35.6	20.4	12.3	.257	.159	.563	1.4	Majumdar <sup>2</sup>

$$\chi^2 = 12.00; P = .007$$

In both the above samples the Korwas are seen to be well saturated with the A and B genes. The value for  $\chi^2$  shows the undifferentiated nature of the two samples. Majumdar's sample shows more A while that of the present author shows more B. Since nothing is known of the nature of intermixture in Majumdar's sample, and since the geographical territory covered by the two sets of data is not very wide, it is difficult to judge the true blood group picture of the Korwas. The value for D/σ of the present sample is high enough to indicate an admixture in the Korwa population. The present author's sample shows the Korwas percentagewise more or less in agreement with the Kharwars, and the high B and AB among the Korwas is possibly due to Kharwar intermixture. In Palamau, Korwa-Kharwar intermixture is still active and it is usually the Korwa females who are seduced.

<sup>2</sup> Majumdar does not give in his paper the absolute number of each of the blood groups in his total of 147. They were calculated as follows: O — 47; A — 52; B — 30; AB — 18, and the corresponding percentages are: 31.97, 35.37, 20.41 and 12.24 respectively. It is not understood how Majumdar got 31.7% and 35.6% for O and A respectively. If O is taken as 46 in place of 47 it comes up to 31.29% while with A as 53 in place of 52 it works out at 36.05%.



*Oraon blood groups.* A suggestive difference in the frequency of O is also seen between the Oraon sample collected from Palamau and an earlier Oraon sample (Sarkar, '42-'43), the majority of which belongs to Ranchi district. These two districts are separated by the Koel river, and in Palamau the Oraons are mostly found in the areas under Garu forest range. In Palamau the forest authorities settled the Oraons in a few villages to facilitate their labor problems in the maintenance of the forest preserves and forest roads.

	O	A	B	AB	p	q	r	D/σ
Oraons (Ranchi) (1942-43)	47.10	12.90	34.84	5.16	.088	.219	.686	0.8
Oraons (Palamau) (1946-47)	26.09	27.83	33.91	12.17	.233	.274	.501	0.4

$$\chi^2 = 19.40; P = .0002$$

A comparison of the above two samples will show that, while the percentage of B is almost the same, the percentage of A and AB in the Palamau sample is more than twice that of the Ranchi sample. There is correspondingly a sharp fall in the percentage of O. This can only be ascribed to an admixture of people high in A to the Oraon population of Palamau. The Korwas are not so abundant in this area, and as in the case of the Korwas, the Kharwars — the predominant population of this area — are to be held responsible. Mention should also be made of the Kisans inhabiting this area. They present a blood group picture similar to those of the Oraons of Ranchi.

It thus appears that the same Kharwars have caused the increase in the frequency of A among the Oraons of Palamau and that of B among the Korwas.

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## THE ABO, RH, AND MN BLOOD GROUPS OF THE SIAMESE

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This paper reports a study of the ABO, Rh and MN blood groups of 213 inhabitants of Bangkok, Siam. The specimens of clotted blood were sent or brought personally from Bangkok to London by air for testing. They were tested with anti-A, anti-A<sub>1</sub>, anti-B, anti-C, anti-D, anti-E, anti-c, anti-e, anti-M and anti-N sera. The anti-C serum had the specificity of anti-C + anti-C<sup>w</sup>. Tests with most of the sera were sharply positive or negative but the specimens had deteriorated slightly in transit from Bangkok to London and results with anti-A<sub>1</sub> and anti-e were not entirely satisfactory. Mathematical tests for internal self-consistency of the results confirmed this impression. The results of testing with anti-A<sub>1</sub> have therefore been disregarded completely. The results in the case of anti-e have been included in the table of observed results but have been disregarded in calculating chromosome frequencies.

In working out gene frequencies our object has been to obtain from the relatively small numbers tested the closest possible approximation to the true values for the population as a whole rather than simply to test our results for self-consistency, though we have done this as well. Bernstein's corrections have therefore been applied to the ABO gene frequencies, calculated by the usual square root method. In the MN system the simple counting of genes has been applied, i.e. frequency of gene M = frequency of genotype MM + half frequency of MN.

In the case of the Rh compound genes or chromosomes we have greatly benefited from discussions with Professor R. A. Fisher, but he is not to be held responsible for our detailed methods. A preliminary estimate is made of the frequency of the CDe chromosome from that of the homozygote. This leads to an estimate of the frequency of the CDE chromosome from the frequency of  $CDe/CDE + CDE/CDE$ . The frequency of the C gene is found by simple counting of CC and Cc genotypes. Since the only chromosomes containing C recognizable in this population are CDe and CDE an improved value for CDe can be got by subtracting CDE from the total C frequency.

TABLE 1  
*ABO groups of the Siamese*

	NUMBER	FREQUENCY %	
		Observed	Expected <sup>1</sup>
O	79	37.09	35.40
A	38	17.84	19.86
B	75	35.21	37.11
AB	21	9.86	7.61
	213	100.00	99.98

<sup>1</sup> For gene frequencies, see table 2.

Since results obtained with anti-e are to be disregarded, the frequencies of the e and E genes are obtained by the square root method from the total frequency of phenotypes not containing E. The only chromosomes with E recognizable in the population are cDE and CDE. CDE is subtracted from total E to give cDE. Finally, cDe is found by difference. The estimate of its frequency carries the errors of the estimates of C and E, but the alternative square root method from the frequency of the homozygote would be liable to much greater error. The differences between observed and calculated phenotype frequencies are small, the largest (in the case of CDe/cDe) being equivalent to an excess of just over three individuals.

Table 2 gives a comparison of our ABO results with Niyomsen's ('45) figures for the ABO groups of people from different parts of Siam which include earlier unpublished observations by Chamuni.

*An anti-N serum.* In the course of preliminary tests carried out at Bangkok on some of the specimens, it was found that

TABLE 2

*Collected observations on ABO groups in Siam (comparative figures from Niyomsen, '45)*

	NUMBER TESTED	PERCENTAGE FREQUENCIES				GENE FREQUENCIES (PER CENT)		
		O	A	B	AB	A	B	O
Bangkok (present study)	213	37.1	17.8	35.2	9.9	14.84	25.66	59.50
Bangkok	600	35.0	18.8	40.1	6.1	13.40	26.76	59.84
Ayuthaya	160	41.3	13.1	41.9	3.7	8.82	26.33	64.85
Lumpang	234	47.4	22.2	28.7	1.7	12.88	16.72	70.39
Bangkok hospital patients	6267	37.3	21.8	33.1	7.8	16.08	23.09	60.84

TABLE 3

*Rh groups of the Siamese<sup>1</sup>*

GENOTYPE	NUMBER	FREQUENCY %	
		Observed	Expected
CDe/CDe	120	56.34	57.06
CDe/cDe	39	18.31	16.81
CDe/cDE	} 35	} 16.43	16.88
cDe/CDE			0.48
CDe/CDE	7	3.29	3.26
cDE/cDE	4	1.88	1.25
cDE/cDe	4	1.88	2.49
cDE/CDE	3	1.41	0.48
cDe/cDe	1	0.47	1.24
CDE/CDE	0	0.00	0.05
	213	100.01	100.00

<sup>1</sup>In calculating gene frequencies the distinction (made by anti-e) between cDE/cDe and cDE/cDE, that between CDe/cDE and cDe/CDE and that between CDe/CDE and CDE/CDE have been disregarded. It will be seen that there is in two of these cases a marked excess of the EE phenotype and a deficiency of the Ec. This is attributed to the weakness of the reactions of anti-e with the rather old cells, as described in the text.

TABLE 4  
*Rh chromosome percentage frequencies of the Siamese*

CDe ( $R_1$ )	75.54
cDE( $R_2$ )	11.17
cDe ( $R_0$ )	11.13
CDE ( $R_z$ )	216
	100.00

TABLE 5  
*MN groups of the Siamese*

GROUP	NUMBER	FREQUENCY, %	
		Observed	Expected <sup>1</sup>
M	91	42.72	43.82
MN	100	46.95	44.75
N	22	10.33	11.43
	213	100.00	100.00

<sup>1</sup> Gene frequencies %: M 66.20  
N 33.80  
100.00

TABLE 6  
*Comparative table of blood group gene frequencies expressed as percentages to the nearest integer*

	INDIA	BURMA <sup>1</sup>	SIAM	JAVA	CHINA
CDe	57	100	75	80	72
cDE	10		11	10	19
cDe	4		11	8	4
Cde	4		0	0	0
CDE	0		2	2	—
cde	25	0	0	0	5
A	15	19	15	18	20
B	25	21	26	18	20
O	60	60	59	65	60
M	62		66	68	58
N	38		34	32	42

<sup>1</sup> The combination Cde is likely to be rare or absent among the Burmese but since the tests of Mollison and Reddy ('46) were carried out with an anti-C + anti-D serum, this cannot be stated categorically.



the serum of one specimen agglutinated the red cells of another. Further investigation in London showed that the serum contained an anti-N agglutinin. It has been described more fully elsewhere (Phansomboon, Ikin and Mourant, '49).

#### DISCUSSION

The chief value of the results obtained lies in their application to the anthropological study of the people concerned. We do not, however, propose in this paper to undertake such a study in any detail but shall attempt merely to show, in the broadest outline, the relation of our results to figures obtained for neighbouring populations.

The only useful comparisons which can be made are with India, Burma, China and Java. ABO, Rh and MN gene frequencies for these countries and for Siam are given in table 6. The results used are based on the work of Prasad, Ikin and Mourant ('48); Mollison and Reddy ('46); Simmons, Graydon and Ouwehand ('45); Wiener, Sonn and Yi ('44), and Ride, '35 (quoted from Boyd, '39). The ABO frequencies for China are an average of the figures quoted by Boyd ('39). Some of the gene frequencies have been calculated by us from published phenotype frequencies.

In all respects there is a particularly close resemblance to Java. Simmons, Graydon and Ouwehand ('45) have shown that Java differs widely from the rest of Indonesia in ABO and MN frequencies. The Rh figures for Java are, however, based on a group of persons including some from the rest of Indonesia as well.

The Siamese ABO figures show the high B frequency which characterises the whole of Asia. In high M frequency Siam resembles on the one hand India and on the other Java, as distinct from the rest of Indonesia which has a high N frequency.

The Rh figures sharply distinguish Siam from the only other Asiatic countries on whose inhabitants full Rh typing has been carried out, notably in the absence of D negative individuals. One such was in fact found in testing 600 Siamese

with an anti-D serum but we were unable to obtain further specimens from this person for confirmation. The high CDe and very low or absent cde characterize the whole Pacific area but here on the whole CDe is even higher and cDe lower than in Siam.

In order to enable full use to be made of the present Siamese figures for ethnological purposes, similar tests on a number of other populations in Southeastern Asia and Indonesia are to be desired, and it is hoped that they will be forthcoming.

Part of the work involved in this paper was carried out by one of us (S. P.) while holding a British Council Scholarship.

#### SUMMARY

Determinations are reported for the ABO, Rh and MN blood groups of 213 inhabitants of Bangkok, Siam. From what comparative figures are available, these Siamese particularly resemble the population of Java. They show the high B frequency characteristic of all of Asia. A high M frequency allies Siam to India and Java, while the rest of Indonesia has a high N frequency. The Rh figures sharply distinguish the Siamese from the inhabitants of other Asiatic countries on whom full Rh typing has been done, notably in the absence of D-negative individuals.

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# THE BLOOD GROUPS AND TYPES OF THE RAMAH NAVAHO

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In the summer of 1948 a joint Harvard-Ohio State expedition carried out a public health, genetic, and anthropological survey of the Navaho Indians living in the vicinity of Ramah, New Mexico. The present authors were privileged to carry out determinations of blood groups and types, as well as to make a number of other observations. The results are reported herewith.

## METHODS

The genealogies of the Indians tested were all known to Prof. Clyde Kluckhohn, the leader of the expedition, and so far as we know, only one family having White mixture was included. This probably means that the group we studied were among the "purest" American Indian groups thus far studied.

The Indians examined were brought a few at a time to the U. S. Indian Hospital at Zuni, New Mexico, where the authorities very kindly allowed us to work, and blood was taken, usually by venipuncture, for the various blood tests, such as the Wasserman. A few drops in a test tube containing 0.9% NaCl solution provided a suitable suspension for the blood grouping tests. Before carrying out the Rh typing, the erythrocytes were centrifuged down, the supernatant removed, and the erythrocytes made up to a 1% suspension (as judged by eye), by the addition of fresh saline. All determinations were carried out in test tubes, the ABO groups and MN types in "Kahn" tubes about  $10 \times 75$  mm, the Rh tests in smaller tubes having an internal diameter of about 5 mm. The anti-A

and anti-B sera were obtained from "stimulated" donors, as already described by one of us (Boyd, '47); anti-M and anti-N sera were prepared by absorbing the serum of rabbits immunized with M and N cells (Schiff and Boyd, '42); anti-R sera were obtained from various laboratories, chiefly from Dr. A. S. Wiener.

Blood from members of the expedition, of known groups and types (including an Rh-negative blood) were included with the unknowns each day, as a check on the strength and specificity of the antisera.

The tests for O, A, B, M, and N were made by putting in the proper tubes one drop of the appropriate antiserum and one drop of a roughly 1% suspension of the blood to be tested. The tubes were shaken, centrifuged, resuspended by vigorous shaking in test tube racks, and the reactions read. The Rh tests were done in a similar way, but the smaller tubes were used, the erythrocytes were first washed, and the mixtures were incubated one hour at 37° before being centrifuged. Then they were shaken one at a time very gently while the bottoms were observed in a mirror on the work bench. With the antisera used there was no difficulty in distinguishing easily between positive and negative reactions.

#### RESULTS

The results for the blood groups and shown in table 1, and the results for taste for phenyl-thio-carbamide and the secretor factor are shown in table 2. The results have been subdivided according to sex only in the case of the taste reaction, since in previous work (Boyd and Boyd, '37) it was found that there was a sex difference in the expression of this character. The gene frequencies for the taster factor and the secreting factor have been calculated on the assumption that non-tasting (Snyder, '32) is determined by a recessive gene in the homozygous state, and similarly for non-secretors (Schiff and Sasaki, '32).

The gene frequencies for O, A, M, and N have been calculated in the usual way (Schiff and Boyd, '42).

TABLE 1

*Frequencies of O, A, B blood groups in Ramah Navaho (in per cent)*

NUMBER TESTED	GROUP				GENE FREQUENCY <sup>1</sup>		
	O	A	B	AB	p <sup>2</sup>	q	r
361	76.7	23.3	0	0	0.124	0	0.876

*Frequencies of M, N types in Ramah Navaho (in per cent)*

NUMBER TESTED	TYPE			GENE FREQUENCY <sup>3</sup>		D/σ <sup>4</sup>
	M	MN	N	m	n	
361	84.5	14.4	1.1	0.917	0.083	0.92

*Frequencies of Rh subtypes in Ramah Navaho (in per cent)*

NUMBER TESTED	TYPE											
	Rh <sub>1</sub> Rh <sub>2</sub> CDe/cDE	Rh <sub>1</sub> Rh <sub>2</sub> CDE/C	Rh <sub>1</sub> Rh <sub>1</sub> CDe/C	Rh <sub>1</sub> rh CDe/c	Rh <sub>2</sub> cDE	Rh <sub>0</sub> cDe	Rh'Rh' Cde/C	Rh'rh Cde/c	Rh'' cdE	Rh'Rh'' Cde/cdE	Rh <sub>1</sub> rh CdE/c	rh cde/c
305	41.0	6.2	22.6	5.9	20.0	0.7	3.0	0	0	0.7	0	0

<sup>1</sup> The gene frequency  $r = \sqrt{O}$ ,  $p = 1 - r$ .<sup>2</sup> Since all the group A's tested for subgroups belonged to subgroup A<sub>1</sub>, it may be considered that  $p_1 = p$ , and  $p_2 = O$ .<sup>3</sup> Gene frequency  $m = M + MN/2$ ,  $n = N + MN/2$ .<sup>4</sup>  $D = 1 - (\sqrt{M} + \sqrt{N})$ ,  $\sigma = 0.5/\sqrt{361}$ .

TABLE 2

*Tasters for PTC and secreting types among the Ramah Navaho (in per cent)*

NUMBER TESTED	TASTERS	NON-TASTERS	GENE FREQUENCIES <sup>1</sup>	
			T	t
Females				
148	98.4	1.6		
Males				
121	98.0	2.0		
Total				
269	98.2	1.8	0.866	0.134
NUMBER TESTED	SECRETORS	NON-SECRETORS	GENE FREQUENCIES <sup>2</sup>	
			S	s
69	98.5	1.5	0.878	0.122

<sup>1</sup> The gene frequency  $t = \sqrt{\text{non-taster frequency}}$ ,  $T = 1 - t$ .<sup>2</sup> The gene frequency  $s = \sqrt{\text{non-secretor frequency}}$ ,  $S = 1 - s$ .



Methods of calculating the Rh gene frequencies, making certain simplifying assumptions, are described by Wiener and Sonn ('46). Calculations giving the best statistical fit would involve computations based on matrices of the order  $8 \times 8$  (Fisher, '46, '47). Since we, like other field workers, did not have all the known kinds of Rh sera available, we could distinguish only 12 of the 27 possibly distinguishable phenotypes, and consequently we have not attempted to fit gene frequencies to our data.

#### DISCUSSION

These results are on the whole typical of what one has come to expect of Indian studies. The 23% group A is contrary to the (now exploded) idea that all pure American Indians belong entirely to group O (Boyd, '39), but percentages of A as high, or higher than this have repeatedly been found (Allen and Schaeffer, '35; Matson, '33). Nevertheless, other American Indian groups are known to possess practically no group A. A recent study showing this has been published by Matson ('47). It seems likely that at least three "layers" of American Indians can be recognized (Boyd, '40; Laughlin, '49): an early layer of pure group O populations, a later layer of populations having a good deal of A, and a more recent layer in the northern regions still exposed to some Asiatic contacts in which there is a good deal of A and some B.

The MN frequencies are very similar to those found by other workers, and reflect the homogeneity of the Indians in respect to these gene frequencies, although the N values found by us are somewhat lower than those usually found. This may reflect the relative freedom from white mixture, or a possible operation of the "Sewall Wright" effect (Boyd, '40) in lowering the frequency of the N gene.

The Rh types are not too dissimilar to those reported for other American Indians (Wiener, '45; Matson, '47). As usual, there is no Rh negative (cde), and the Rh<sup>z</sup> (CDE) gene is much more frequent than in European populations. A considerable proportion of our Rh<sup>z</sup>'s were confirmed by retests.

As with other American Indians, all those of group A belong to subgroups A<sub>1</sub>, and practically all individuals tested were tasters for PTC and belonged to the secretor type (table 2). In blood group frequencies, except for the absence of blood group B, American Indians are Asiatic in type, and are differentiated chiefly by the low N frequencies. These two important differences, however, seem enough to enable us to distinguish them serologically as a separate race.

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#### SUMMARY

Studies on over 300 Navaho Indians living in the vicinity of Ramah, New Mexico, showed about 23% group A, 1% type N, and no Rh negatives. The other Rh subtypes were similar to those previously observed in other American Indian and Asiatic groups. Only one individual tested was a non-secretor, and the incidence of non-tasters for PTC was very low.

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GENETIC FACTORS IN GOUT.—Asymptomatic hyperuricemia is a frequent finding in the relatives of patients with gout. Statistical analyses indicate that a single gene is probably responsible for the transmission of asymptomatic hyperuricemia; that this gene is dominant rather than recessive; and that the responsible gene is autosomal rather than sex-linked . . .

The data suggest a correlation between the duration and magnitude of hyperuricemia and the occurrence of clinical gout. The results are consistent with the view that clinical gout develops more frequently in males who inherit hyperuricemia because of three factors: (a) the plasma urate concentration of males is normally greater than that of females; (b) the gene responsible for the inheritance of hyperuricemia appears to be somewhat more effective in regard to the actual quantitative magnitude of elevation of the plasma urate level in males; and (c) since males who inherit hyperuricemia develop their maximal urate levels considerably before female carriers, this increased duration of hyperuricemia exposes the males to a proportionately increased risk of developing clinical symptoms.—Charley J. Smyth, Robert M. Stecher and William Q. Wolfson. Genetic and endocrine determinants of the plasma urate level. *Science*, n.s., vol. 108, no. 2810, November 5, 1948, pp. 514-515.

# BLOOD GROUPS OF INDIANS, WHITES AND WHITE-INDIAN MIXTURES IN SOUTHERN MATO GROSSO, BRAZIL <sup>1</sup>

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## ONE FIGURE

The southern part of the Brazilian State of Mato Grosso has 260,000 inhabitants, mainly Whites, Indians and mixtures of these two groups. There are also a few Negroes, Mulattoes and "Cafuzos" (Indian-Negro crosses). Of course, too, a small percentage of the people have Indian-White-Negro blood.

The white population has been derived from "Gauchos" (inhabitants of the State of Rio Grande do Sul), "Mineiros" (inhabitants of the State of Minas Gerais), and "Paulistas" (inhabitants of the State of São Paulo). The Gauchos, who are in the majority, immigrated from their State on account of continuous political disturbances, and found the climate of southern Mato Grosso quite similar to that of their birth-place.

Since the end of the last century, Paraguayan influences, both ethnic and economic, have increased. Recently, however, greater inducements have been offered Brazilian colonists because of the establishment of the Noroeste Railroad and other means of communication, the industrial development of São Paulo State by the agricultural colonies in the Municipality of Dourados, and the administrative autonomy (during 1943-46) of the greater part of the region formerly

<sup>1</sup> The writer is indebted to Mr. Guilherme Guinle for a grant for this investigation.

included in the Federal Territory of Ponta Porã. As a result native Brazilians are becoming predominant in the population.

The principal Indian groups of the region are the Tereno,<sup>2</sup> the Caiguá, and the Caduvéo (Guaicurú) tribes, living in villages organized under the "Serviço de Proteção aos Índios" Federal Brazilian Bureau for Protection of the Indians). In these villages are also a few Guarani, Layana, Quinquinao and Chamacoco Indians. There are frequent inter-tribe crossings. Isolated groups of Guarani and Tereno Indians have been identified near the Igatemy River, on the Paraguayan frontier and some families of Opayé-Shavante in regions near the Paraná and Pardo Rivers.

The White-Indian mixtures, commonly called "Caboclos," represent all degrees of crossing with the Indians of these various tribes. There are found also a few mixed descendants of Paraguayan Indians (Guaná, Chamacoco, Guarani, etc.), and even of the Indians from the northern part of the State, mainly the Bororo.

The Indians of this region raise cattle and engage in agriculture. In the Municipalities of Ponta Porã and Dourados, they cultivate and prepare "herva mate" (south-tea or Paraguayan tea). At the villages of Taunay and Lalima there are some craftsmen. Yet in spite of a certain degree of western civilization, the Indians still preserve traits of their original culture, although this varies from place to place. The Caiguá and Guarani speak Guarani, but speak Portuguese very badly; the Tereno and Caduvéo, too, speak both their own dialects and Portuguese; the Layana and Quinquinao formerly spoke the Tereno dialect along with Portuguese.

#### MATERIALS AND METHODS

During May and June of 1947 I made a trip to the southern part of the State of Mato Grosso, where I had an opportunity

<sup>2</sup> Spellings of tribal names conform to those adopted by the Bureau of American Ethnology for its "Handbook of South American Indians" (Bull. no. 143, vol. 1, 1946) — Ed.



to investigate the serological aspects of local ethnic mixture. Of this mixture the present paper will deal only with White-Indian combination.

In a previous paper (da Silva, '48), I have shown that in dealing with complicated ethnic mixtures, it is better to characterize the original components before defining their mixtures. For this reason, it was found necessary to obtain data on local pure Whites and Indians. The subjects studied (fig. 1) come from the towns of Bela Vista, Ponta Porã, and Campanário; the villages of Esperança, Porto Felicidade and Amambáí (Patrimônio da União); and the Indian villages of Taunay (3 km from the town of Taunay), Cachoeirinha (9 km from the railroad station of Duque Estrada), Lalima (120 km from the town of Taunay, near the Miranda River), Benjamin Constant (6 km from the town of Amambáí), Reserva Cerro Peron (40 km from the villages of Amambáí and 12 km from the town of Antonio João, former Nhuvera), José Bonifacio or Tei-cuê (90 km from Ponta Porã), and Francisco Horta (5 km from the town of Dourados). This is a large region, with a total surface of 31,700 km<sup>2</sup>. The density of population is 1.47 inhabitants per square kilometer. Moreover population movement is very active, for which reason the region will be considered as a whole.

The blood (in a total amount of about 0.5 ml) was collected in capillary tubes, three of them for each individual. Each tube was wrapped in a serially numbered paper. Then the samples were taken to an emergency laboratory, at a hotel or in a village, the tubes were broken and the blood put in special tubes containing 1 ml of saline. By shaking we obtained a blood cell suspension of about 2%. Drops of this suspension were added separately to drops of the three sera O, A and B on glass slides and mixed.

The average temperature during most of the trip was +15°C., but occasionally the temperature went down to +4°C., and there was a heavy frost. Under these conditions the samples were well preserved even 10 days after collection.



Indians objected that they were not sick and thus they did not need any blood examination. A rough clinical examination followed by prescription and even the distribution of some medicine settled the question.

#### RESULTS

Table 1 shows that the Indians of the region under consideration belong uniformly to group O. This is the usual finding among the Indian tribes of South America (da Silva, in press). Recently I have found this to be true also of the Bororo of São Lourenço (northern Mato Grosso). On the other hand, I have found the workers of the Brazil-Bolivia Railroad, in the region between the cities of Corumbá and El Carmen, where there is considerable White admixture, to have only 72% of group O.<sup>3</sup>

Two samples of the White population were studied and the results require their separate consideration. The first series, totalling 172, was obtained in the town of Campanário and in the villages of Esperança, Porto Felicidade and Amambáí, located about 150 km from the Brazilian-Paraguayan frontier. This series contained about 54% group O, a high percentage that can be explained only by the influence of Brazilian or Paraguayan Indians. All around the region the Guaraní language is widely spoken, even by the new-Brazilians.

A different blood group distribution was seen in the second series, 84 white children from the São José Parish School in the city of Ponta Porã. The occurrence of O among these children is quite low, about 44%, and on the whole, the occurrence of the four blood groups is similar to that of a typical White population. This finding is explained by the fact that these children are mainly of Syrian, Turkish, Jewish and Portuguese stocks, with very little, if any, Indian admixture.

<sup>3</sup> Unpublished data.

TABLE 1  
*Blood group distribution in southern Mato Grosso*

ETHNIC GROUP AND LOCALITY	No.	BLOOD GROUPS							
		Numerical distribution				Percental distribution			
		O	A	B	AB	O	A	B	AB
<i>Indians</i>									
7 tribes	587	587	0	0	0	100.0	0	0	0
<i>Mixed</i>									
Ponta Porã	174	106	49	17	2	61.0	28.1	9.8	1.1
Bela Vista	43	27	10	5	1	62.8	23.3	11.6	2.3
Total	217	133	59	22	3	61.3	27.2	10.1	1.4
Campanário	106	74	26	5	1	69.9	24.5	4.7	0.9
<i>Whites</i>									
Lalima	58	38	12	3	5	65.5	20.6	5.2	8.6
Taunay, Ipegue and Caehoeirinha	63	53	5	5	0	84.0	8.0	8.0	0
Francisco Hortã	42	38	4	0	0	90.4	9.6	0	0
Total	163	129	21	8	5	79.2	12.9	4.9	3.0
<i>Whites</i>									
Campanário	172	94	53	18	7	54.7	30.8	10.4	4.1
Ponta Porã	84	37	35	9	3	44.1	41.6	10.7	3.6

Blood samples of the mixed population were taken in the same places as those of the Whites. Three mixed series are represented:

(a) One-hundred and seventy-four children from the city of Ponta Porã (Mendes Gonçalves School), and 43 soldiers from Bela Vista. These two groups may be considered together because they fail to show any significant difference in the occurrence of blood groups O (between 61% and 63%) and B, although they show a significant difference in group A.

(b) One-hundred and six subjects from and near Campanário. Here the proportion of O individuals was greater (69.9%) and of A and B individuals correspondingly lower than in the foregoing series. These 106 mixed subjects are a little nearer the Indians, by which is to be understood that the Paraguayans have predominated in the population of Campanário and nearby regions for a long time. There are many reports, mainly Urizar's ('42), showing a high percentage of group O in Paraguayan territory, and even in the Capital. Furthermore, I have determined that group O predominates among some of the Indians from the Chaco region.<sup>4</sup>

(c) The third series consists of three groups of mixed peoples from the Indian villages of the region. These groups give extremely significant results. Incidence of group O reaches 79.2%, no doubt in consequence of the high amount of Indian blood. The group from each Indian village shows a different O value: 65.5%, 84.0% and 90.4%. It is to be emphasized that these figures reflect the racial composition of the groups, and also the duration of the racial crossing involved. These facts strengthen the observation of the predominance—if not the exclusive incidence—of the gene *r* in the Indians of the region. In view of Urizar's ('42) report, this observation probably can be broadened to include the Indians from the Paraguayan region of the Great Chaco.

<sup>4</sup> Unpublished data.



Generally speaking, the population of the region includes very complex breedings of Indians and Whites. I believe, however, that the data in table 1, based on a total of 1,329 blood group determinations of these groups, is quite representative of the border region between Brazil and Paraguay.

In table 2 are shown the percentages of the genes  $p$ ,  $q$  and  $r$  in the various series.

That these figures are statistically satisfactory is shown by the fact that the difference ( $D = 1 - [p + q + r]$ ) exceeds

TABLE 2  
*Gene frequencies in southern Mato Grosso*

ETHNIC GROUP AND LOCALITY	NO.	GENE FREQUENCY			DIFFERENCE AND STANDARD DEVIATION
		p	q	r	
<i>Indians</i>					
7 tribes	587	.0	.0	1.000	.0
<i>Mixed</i>					
Ponta Porã	174 }	.155	.059	.783	.003 $\pm$ .0016
Bela Vista	43 }				
Campanário	106	.136	.028	.836	.0
Lalima	58	.158	.072	.809	.039 $\pm$ .0180
Taunay, Ipegue and Cachoeirinha	63	.041	.041	.916	.002 $\pm$ .0037
Francisco Hortã	42	.048	...	.951	.001
Total	163	.082	.039	.890	.011 $\pm$ .0010
<i>Whites</i>					
Campanário	172	.193	.075	.739	.007 $\pm$ .0023
Ponta Porã	84	.260	.074	.664	.002 $\pm$ .0041

three times its standard deviation in only one case.. This fact justifies the employment of these figures in the calculation of the ethnic composition of mixed groups, using the formula recommended by Ottensooser ('44) and recently employed by the writer ('48).

The blood group distribution among the mixed people under consideration is, obviously, intermediate to that of typical Indians and Whites; a series of the mixed may be 50% White-50% Indian, 75% White-25% Indian, and so forth. Of

course, the racial composition of a group may be quite different from that of any one individual within the group.

There is no problem in the comparison of the mixed people with the Indians, for the latter belong 100% to group O. As for the Whites, however, there exists for each gene two reference values; first, the proportion of that gene in a typical White population, and second, the proportion of that gene among the White people of the locality, some of whom have already acquired traces of the Indian strain, being in reality a mixed group, in spite of their pure White appearance.

Let us see the results of the simple algebraic calculation for degree of mixture summarized in table 3.

Using the gene values for a typical White population, it is apparent that the mixed people from Ponta Porã are about 40% Indian and therefore about 60% White. There is good agreement here between the values obtained independently with genes  $p$  and  $r$  (43% and 38% respectively).

The mixed people from Campanário and nearby regions show that they are 50% Indian. Here again there is a satisfactory agreement between the values given by  $r$  and  $p$  (53% and 49% respectively).

For the mixed people from the Indian villages, the figures are much higher. They are practically 70% Indian and 30% White. Here the agreement between the calculations with  $r$  and  $p$  is still good (69% and 70% respectively).

However, if we use the gene values for the local "White" population, probably not pure in the sense of being entirely free of Indian inheritance, we obtain quite different figures. Now the mixed peoples appear to have a much higher amount of White blood: Those from Ponta Porã have approximately 20% Indian blood instead of 40%; those from Campanário, where the smaller number of observations causes a broader variability, have from 30–35% Indian blood instead of 50%; and those from the Indian villages have 60% Indian blood, instead of 70%.

The data on the mixed peoples from the Indian villages have been analyzed further in table 3. In spite of the fact that these data concern small groups, they bring out some significant differences.

Basing calculations on the typical White population, the cross-breeds of Lalima are 50% Indian, those from Taunay, Ipegue and Cachoeirinha are 75% Indian; and those from the village of Francisco Horta are 85% Indian and only 15%

TABLE 3

*Composition of various White-Indian groups in southern Mato Grosso*

GROUP	NO.	CALCULATIONS BASED ON GENE FRE- QUENCIES OF TYPICAL WHITE POPULATION <sup>1</sup>		CALCULATIONS BASED ON GENE FRE- QUENCIES OF LOCAL "WHITE" POPULATION <sup>2</sup>	
		Gene $r$ <sup>3</sup> Gene $p$ <sup>3</sup>		Gene $r$ <sup>3</sup> Gene $p$ <sup>3</sup>	
		% <i>Indian</i>	% <i>Indian</i>	% <i>Indian</i>	% <i>Indian</i>
Ponta Porã and Bela Vista	217	38	43	17	20
Campanário	106	53	50	37	30
Lalima	58	45	41.5	27	18
Taunay, Ipegue, Cachoeirinha	63	76	85	68	78
Francisco Horta	42	86	82	81	75
Total — Lalima, Taunay, and Francisco Horta	163	69	70	58	58

<sup>1</sup> Typical White population:  $r = .65$ ;  $p = .270$ ;  $q = .08$ .

<sup>2</sup> Local "White" population:  $r = .739$ ;  $p = .193$ ;  $q = .075$ .

<sup>3</sup> For formulae, see this Journal, n.s. 6: 425, table 2.

White. Smaller percentages of Indian blood result from the calculations based on the local "White" population.

It is noteworthy that an intimate correlation exists between the degree of ethnic mixture and the degree of culture change in all these tribes. Indeed at the villages where the mixed people present only 50% of Indian blood, only a few traits of the original Indian culture are preserved. On the contrary, at the villages of Francisco Horta, with 85% Indian blood, the loss of the primitive culture is much less advanced.

## SUMMARY

The blood groups in Whites, Indians and White-Indian mixtures ("Caboclos" or "Mamelucos") from southern Mato Grosso were determined. The Indian tribes included were the Tereno, Caiguá, Caduvéo (Guaicurú), Guaraní, Layana and Quinquinao.

Part of the Whites are shown to have gene frequencies atypical of White populations in general, whereas the remainder vary in such a way as to suggest slight Indian admixture. The pure Indians all belong to group O.

From the gene frequencies of the Whites and Indians, the composition of several mixed groups has been computed. In general the results parallel the process of culture change; in other words, the least civilized groups have the highest percentages of Indian blood, and vice versa.

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ESTIMATES OF RACE MIXTURE IN POLYNESIA.—A sufficiently accurate summary of the claimed number of mixed bloods in sample Polynesian population is given in the following table.

ISLAND GROUP	CENSUS DATA	NUMBER OF MIXED BLOODS	PER CENT OF MIXED BLOODS IN TOTAL POPULATION
Cook islands	1945	1910	14.0
Niue	1945	211	4.9
Tonga	1938	477	1.4
Western Samoa	1947	5134	71.0
American Samoa	1938	1303	10.1
Fiji	1946	6142	2.3
Gilbert and Ellice	1947	523	1.5

(In a personal communication, Mr. H. E. Maude, until recently Resident Commissioner, Gilbert and Ellice Islands Colony, informs me that the [above] noted percentage of mixed-bloods in the Gilbert and Ellice Islands grossly underestimates the real numbers. Alien blood is so widely distributed throughout the Gilbert and Ellice Islands that a very large proportion of the native population is, in fact, of mixed blood, and the number of pure-bloods is consequently very small.)

Reliable statistics for the French Establishment are not available owing to changes made by the French from time to time in their census enumerations. For south and west Polynesia, however, the range of mixed bloods in the general population is from 1.4 to 14%. But as already indicated, these percentages undoubtedly underestimate the actual amount of race mixing, even though the range of percentages probably gives a rough idea of the relative amounts of intermixing in the populations concerned. In many island groups in addition to those noted in the table, the number of mixed bloods have been materially increased by war-time garrisons of armed forces. A recent estimate for example indicates that in Aitutaki, Lower Cook Group, about 70 of a total of some 800 children under the age of 5 years are of recent mixed American-Aitutaki descent.

Apart from special war-time circumstances and with the exception of areas where separate mixed blood groups exist, there has always been a tendency for the mixed blood to marry back into the indigenous population. Thus there is a tendency in many islands for the mixed-blood to be absorbed biologically and socially into the dominant native population, leaving behind only Polynesian variants of European names as evidence of previous European contact. By the time European mixture has been diluted to a thirty-second or a sixty-fourth, as must be the case many times over in the Cook Islands, for instance, the influence of European heredity must be negligible biologically, and survive socially only in some vague family tradition or cherished inconsequential family heirloom.—

Ernest Beaglehole. The mixed blood in Polynesia. *J. Polynesian Soc.*, vol. 58, no. 2, June, 1949, pp. 51-57.



## GENE FREQUENCIES AND RACE MIXTURE

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If two populations interbreed, the resulting hybrids are generally intermediate in character. The final result will depend on the numbers of the parental populations and the mode of inheritance of the features we choose to examine.

If the characteristics of the latter are determined by a known number of genes acting in a known manner, we can make quantitative predictions about the hybrid population, just as a chemist might predict the percentages of Cl in a mixture of  $b$  parts of NaCl and  $c$  parts of KCl. Bernstein ('31) showed how such calculations could be made for the ABO blood groups and also mentioned that the calculations could be reversed in dealing with problems of mixture. The reverse of the process is exactly analogous to the calculations of "indirect analysis" in quantitative chemical analysis (see, for example, Fales and Kenny, '39) and involves no new principle. Examples of such calculations have been published by Wiener ('43), Boyd ('39), Ottensooser ('44) and da Silva ('48).

Laughlin ('49) recently examined the MN blood types in the Aleutian Islands. He found for one probably mixed population a gene frequency  $n = 0.171$ . It was of interest to determine, if possible, how much White mixture this population had received during the days of Russian rule. Assuming that the original Aleut population had a value of  $n = 0.087$  (the value found by Fabricius-Hansen, '39, for the Eskimo of Angmasalik), and assuming for the Russian element the value of  $n = 0.417$  (the value found by Boyd and Boy, '37, for the Russians of Kharkov) it is possible to calculate very simply the amount of Russian "blood" in the present Aleutians. Let

$n_R$  = the N frequency of the Russians,  $n_A$  = the N frequency of the Aleuts, and  $n_E$  = the N frequency of the Eskimo who are assumed to be similar to the original Aleuts. Then the usual algebraic processes lead us to the equation

$$\frac{n_A - n_E}{n_R - n_E} \times 100 = \text{percentage of Russian mixture.}$$

Substituting the values given above, we obtain

$$0.084/0.330 \times 100 = 24.45\% \text{ Russian mixture.}$$

Laughlin ('49) concludes that this value is consistent with other observations on the Aleuts.

In the case of the MN blood types, no problem of estimation of the gene frequencies arises, for they are given directly by the relations  $m = M + MN/2$ ,  $n = N + MN/2$ . But in the case of the ABO blood groups, since the heterozygotes cannot all be recognized directly, the exact gene frequencies  $p$ ,  $q$ , and  $r$  cannot be determined, and instead estimates must be made based on the observed phenotypic frequencies. Two simple ways of estimating  $p$ ,  $q$ , and  $r$  have been proposed. The first, by Bernstein ('25), employs the relations (*italic symbols indicate frequencies*):

$$\begin{aligned} r &= \sqrt{O} \\ p &= 1 - \sqrt{O + B} \\ q &= 1 - \sqrt{O + A}. \end{aligned}$$

The second method, apparently first published by Wiener ('29) uses:

$$\begin{aligned} r &= \sqrt{O} \\ p &= \sqrt{O + A} - \sqrt{O} \\ q &= \sqrt{O + B} - \sqrt{O} \end{aligned}$$

If the population being tested is in genetic equilibrium, and the group determinations are correctly done, these two methods will give identical results, except as influenced by sampling errors. When the populations tested are small, and not in genetic equilibrium, the two methods may yield results which differ rather widely. An example of this is to be found in the paper by da Silva ('48), who tested Whites, Negroes, and mulattoes in Brazil, and attempted to estimate from the

resulting blood group frequencies the proportion of White and Negro "blood" in the mulattoes. Using the frequencies of the gene A ( $p$ ), he estimated, when he employed the Bernstein formulas, that the mulattoes were 52.7% Negro. Using the Wiener formulas, the results would be 32.8% Negro. Clearly these values differ more than would be desirable, and the question arises: which is more nearly correct? Da Silva apparently assumed that the most nearly correct value would be arrived at by averaging the two sets of gene frequencies for each population, and then carrying out the calculation of the degree of mixture. He thus obtained the value of 44.3% Negro mixture.

The procedure used by da Silva would not usually give the best estimate of the proportion of Negro to White in the ancestry of the mulatto population, because neither the Bernstein nor the Wiener formulas give the best estimate of the gene frequencies from the data employed, nor does an average of the two. Stevens ('38) has shown how the best statistical estimates can be arrived at, for any given set of data, by Fisher's method of "maximum likelihood." It is clear that the best notion of the degree of mixture will be obtained if we base our calculations on the best estimates which we can make from the data.

If we apply Stevens' methods to the data of da Silva, we obtain the estimates shown in table 1. From them, using the values of  $p$ , we can calculate that the mulattoes represent 50.8% Negro. This is obviously the best value we can estimate from  $p$ , but it is also obvious, from the size of the standard errors of the values, that it cannot be too precise, since the samples are small, and some of them, at least, do not seem to represent populations in genetic equilibrium. It is interesting to note, however, that da Silva's estimates of the degree of mixture, based on the Bernstein formulas, are closer to the best estimate than his results obtained from the values of  $p$  obtained by averaging the results of the two formulas. His first estimate is 1.9 points too high, but his second (average) result is 6.5 points too low. Thus the Bernstein formulas gave

the better results in the present instance. In other cases it would be expected that the Wiener formulas would be preferable. But in all cases it would seem best to base calculations of mixture on the maximum likelihood estimate of the gene frequencies.

Estimation of gene frequencies by the method of Stevens is not very difficult, and has the advantages that the frequencies obtained add up exactly to 1.0000, and that the standard deviations can easily be calculated. However, Bernstein ('30) proposed a method which is simpler mathematically, and which,

TABLE 1

*Blood group gene frequencies calculated by various methods (from da Silva's data)*

	GENE FREQ.	BERNSTEIN ( '25)	WIENER ( '29)	AVERAGE	STEVENS ( '38)	BERNSTEIN ( '30)
Negroes	p	.133	.108	.121	.131 ± .018	.131
	q	.147	.122	.135	.145 ± .018	.145
	r	.745	.745	.745	.724 ± .024	.723
Mulattoes	p	.202	.186	.194	.202 ± .025	.200
	q	.112	.096	.104	.111 ± .019	.111
	r	.702	.702	.702	.687 ± .029	.688
Whites	p	.279	.224	.252	.274 ± .025	.271
	q	.125	.070	.098	.199 ± .016	.122
	r	.651	.651	.651	.067 ± .027	.606

as Stevens ('38) points out, gives values also satisfying exactly the maximum likelihood equations. Bernstein wrote:

$$p' = p \left( 1 + \frac{D}{2} \right)$$

$$q' = q \left( 1 + \frac{D}{2} \right)$$

$$r' = \left( r + \frac{D}{2} \right) \left( 1 + \frac{D}{2} \right)$$

where  $p'$ ,  $q'$ , and  $r'$  are the corrected estimates of the gene frequencies of A, B, and O respectively,  $p$ ,  $q$ , and  $r$  are the estimates obtained from the original Bernstein equations, and  $D = 1 - (p + q + r)$ .

It is well worth while to adjust the gene frequencies as calculated by the original Bernstein or Wiener methods. For both methods employ the inefficient estimate  $r = \sqrt{O}$ . In the case of the "White" group examined by da Silva, using this inefficient estimate instead of the efficient estimate is equivalent to rejecting 22 of the 196 observations.

The present writer regrets that in his compilation of blood group data for various populations (Boyd, '39) he did not have time to compute adjusted frequencies for the various populations concerned, and still worse, did not do the calculations of gene frequencies by the Bernstein formulas, so that the gene frequencies he gave cannot be adjusted by the simple formulas given above. The method of Stevens can, however, be applied whenever desired to the blood group frequencies in the tables, and will give the best possible statistical estimates.

Finally, it may be stated that it might well be doubted if da Silva's mulattoes are really the result of mixture of the Negro and White populations he examined. The value of  $p$ , it is true, is compatible with the assumption that the mulattoes represent a cross of the other two groups in about equal numbers, but the values of  $q$  (frequency of gene B) are not, for we find the mulattoes to have a value of  $q$  ( $0.111 \pm .019$ ) lower than that for Negroes ( $0.145 \pm .018$ ) or Whites ( $0.119 \pm .016$ ), a result impossible from mixture alone. On the other hand, if we examine data on American Negroes, for example from New York City, we find  $p$  higher than in West Africa, and  $q$  lower, in about the amounts expected from roughly 40% white mixture. In any precise calculations we should make use of information furnished by both  $p$  and  $q$ , but such calculations would not be worthwhile unless we knew rather precisely the genetic composition of each population entering into the mixture.

In making the best estimate of gene frequencies for more complicated cases, such as the Rh blood types, the method of maximum likelihood may be employed, and Fisher ('46, '47) has given an example of its use in such calculations. The cal-



culations are somewhat more complicated, as matrices of the 6th or 8th order are employed, but the principle is the same.

A simple method of estimating the Rh gene frequencies has been offered by Wiener and Sonn ('46), making use of certain simplifying assumptions. This does not, however, give the maximum likelihood solutions.

#### SUMMARY

Attention is called to the importance of using the best estimates of gene frequencies in calculating the proportions in which two known populations must have mixed to produce a given population of hybrids, and data on natives of the Aleutian Islands and of Brazil are used as illustrations.

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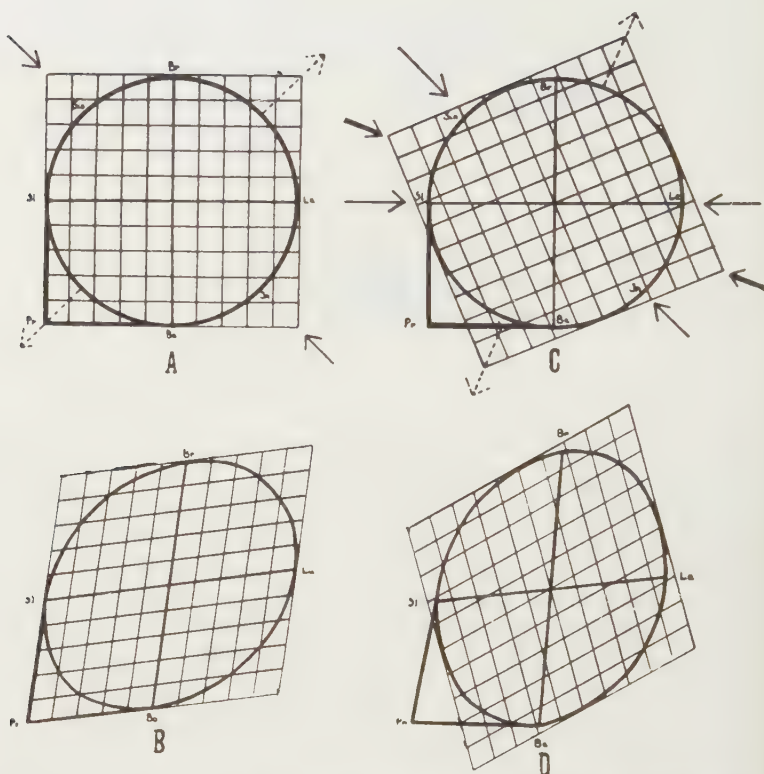
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**SCHEMATIC INTERPRETATION OF DEFORMITY TYPES.**—With a view to ascertaining and demonstrating how the median section of a skull changes in shape when the skull is subjected to deformation (whether occipito-frontal or circular) of in the one case lambda type and in the other inion type, we have employed a purely schematic method and made the median sagittal curve (glabella-bregma-lambda-basion) constitute the arc of a sector of  $270^\circ$  [fig. A]. As will be apparent from the figure, the arcs of glabella-bregma, bregma-lambda and lambda-basion have each been supposed to contain  $90^\circ$ . In this figure the facial skeleton has also been schematically represented by the registration of the distances glabella-prosthion and prosthion-basion which have each been given the same length as the radius of the circle and are therefore at right angles to each other.

In the inion type the heaviest deforming pressure is applied as shown by the whole-drawn arrows in figure A . . . In this way the vertex of the bregma-lambda arc is displaced in the direction of the upper dotted arrow in figure A, and the arc is given increased curvature and a shorter chord, see figure B. In the same way the prosthion region is displaced in the direction shown by the lower dotted arrow in figure A, and the prosthion angle becomes more acute, see figure B. As will be seen from figure B, also Klaatsch's central angle, i.e., the upper anterior angle between the basion-bregma axis and the glabella-lambda axis will be widened in this type of deformation.



In the lambda type of deformation the deforming pressure acts as shown by the whole-drawn arrows in figure 6 . . . The resultants of these pressure forces will therefore act as indicated by the double-contoured arrows in figure C . . . The anterior portion of the bregma-lambda arc becomes more curved, while its lower portion is flattened out. The prosthion angle becomes somewhat more acute although not in such a high degree as in the inion type. The widening of Klaatsch's central angle in this deformation type does not become so pronounced as in the inion type.— Carl-Herman Hjortsjö and Johannes Lindh. Anthropological investigations of the cranial and skeletal material from Dr. Stig Rydén's archaeological expedition to the Bolivian highlands, 1938-1939. Appendix 2 from "Archaeological researches in the Bolivian highlands" by Stig Rydén, Göteborg, 1947, 43 pp.

## BRIEF COMMUNICATION

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### A VICE TO FACILITATE THE MEASUREMENT OF SMALL SKULLS

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TWO FIGURES

In the course of craniometric and odontometric studies of the green monkey — *Cercopithecus aethiops sabaeus* — it became evident that an instrument in which the cranium could be easily and rapidly fixed in any position was necessary so that the operator could have both hands free to manipulate measuring instruments. The vice illustrated and described in this note was designed to meet these needs.

The skull is held between the jaws of the vice, both of which are capable of vertical and rotatory movements. Only one (1) is movable horizontally; the other (2) is fixed to a metal plate (3) which forms one end of the base. Each jaw consists of a perspex block padded with surgical felt, and retained on a vertical metal plate by a brass pin (4). The head of this pin forms a handle for the vertical and rotatory movements of the perspex block, which are permitted by a vertical slot (5) in the plate, and controlled by a spring washer (6) inserted between the plate and the perspex block. The base of the instrument (7) is a box with hardwood sides and a metal top in whose center is a slot (8). The metal ends (3 and 9) form bearings for a threaded rod (10) carrying a hand-wheel (11) at one end. This regulates the horizontal movement of the sliding jaw (12). The lower end of the vertical plate carrying the movable jaw is attached to a right-angled bracket

(13) riding on the metal top of the base. This bracket, together with its attached plate and jaw can travel horizontally. A short block (14) sliding accurately in the slot in the metal top, and slightly thicker than this, is screwed above to the bracket carrying the movable jaw, and below, to an inverted

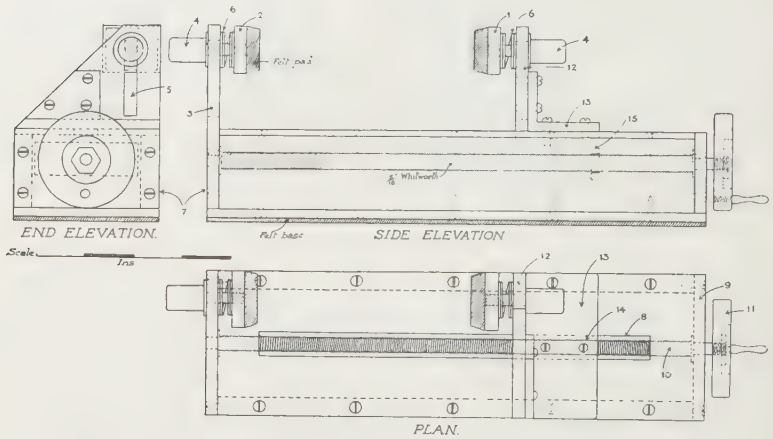


Fig. 1 Plan and elevations of the vice. One-quarter natural size.

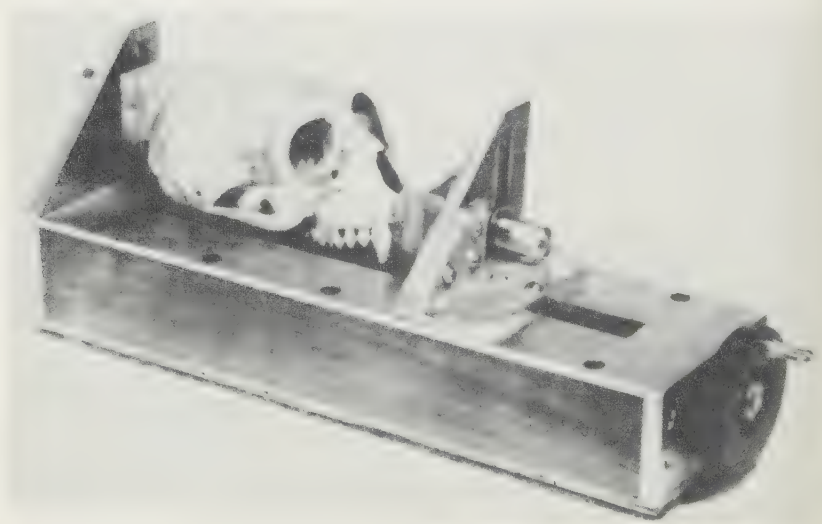


Fig. 2 A monkey skull mounting for taking coronal measurements.



bracket (15) which is drilled and tapped in line with the threaded rod (10), and serves to transmit its movement to the sliding jaw. The front portions of the metal plates are cut away to allow greater freedom of access to the cranium.

For taking sagittal measurements of the skull, the jaws of the vice grip the zygomatic arches. When in this position, the skull may be tilted by vertical and rotatory movements of the jaws of the vice, and either the face or the occiput immediately made accessible. For coronal measurements, one jaw of the vice is adjusted to grip the opisthocranium, and the other the maxillary incisors (see fig. 2). A mandible may be secured for taking labio-lingual measurements of the premolar and molar teeth, by gripping the lower incisors against the movable jaw, and by supporting the condylar processes against a padded metal plate placed in front of the semi-movable jaw. This plate is fitted with a base which rests on the metal top of the instrument.

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The author acknowledges the help given by Mr. W. J. Pardoe in the design and preparation of this instrument.

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## REPORT ON ANTHROPOLOGICAL INSTRUMENTS MANUFACTURED IN SWITZERLAND

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During a recent trip to Switzerland for the purpose of lecturing and working in the Universities of Zürich and Berne,<sup>1</sup> I was able to visit a firm which is now ready to supply the majority of the anthropological instruments described by R. Martin in his *Lehrbuch der Anthropologie* (2nd edition, Jena, 1928). I was offered every opportunity to examine a large

<sup>1</sup>I am very grateful to the Viking Fund for a generous grant in support of this trip.

assortment of these instruments and found them to be of excellent quality and equal in every respect to the well-known older models. Unfortunately, the prices are very high, partly on account of the present unfavorable rate of exchange of slightly less than 4 Swiss francs for the dollar. All these instruments are being manufactured by *Gneupel Präzisions-Mechanik* at Dübendorf (near Zürich) and are sold and distributed by Siber Hegner and Co. in Zürich (Talstrasse 14) who also have an office in New York (183 Madison Avenue, New York 16, N. Y.) which is most convenient to deal with for American purchasers of these instruments.

The following list of the Gneupel concern contains all the instruments made at present, and refers throughout to Martin's *Lehrbuch* (2nd edition) in which full descriptions and, often, illustrations of these instruments can be found on the pages (p.) and in the figures (f.) given here for each instrument in parentheses. The prices are listed in Swiss francs (S.F.), as quoted last July, and do not include the cost of packing, shipping and insuring. The latter cost, I was informed, averages generally about an additional 7% of the price of the instrument.

1. *Anthropometer*: with millimeter scale 0-2000 mm combined with beam caliper with second millimeter scale 0-950 mm and without curved measuring arms (with canvas case) (pp. 129 and 131, ff. 50 and 52). S.F. 415.
2. *Two curved measuring arms*: for the beam caliper or top part of instrument 1 (p. 132, f. 53). S.F. 90.
3. *Auricular height needle*: for the beam caliper of instrument 1 (p. 132). S.F. 53.
4. *Sliding caliper*: size 250 mm with millimeter scale on both sides, pointed and flat ends on arms, millimeter scale at free end of ruler for measuring depth of nose (p. 127, f. 49). S.F. 110.
5. *Sliding caliper*: Poech type with movable arms, 250 mm. (p. 128, "2 b"). S.F. 280.
6. *Spreading caliper*: with millimeter scale to 300 mm and rounded ends (p. 125, f. 48). S.F. 180.
7. *Spreading caliper*: same as instrument 6, but with pointed ends. S.F. 180.
8. *Spreading caliper*: large size, millimeter scale to 600 mm, with rounded ends (p. 126, "1 a"). S.F. 325.
9. *Spreading caliper*: same as instrument 8, but with pointed ends. S.F. 325.

10. *Steel measuring tape*: 2000 mm long (p. 133). S.F. 18.
11. *Canvas instrument case*: containing instruments 4, 6 and 10 and a dermatograph (p. 230, f. 83). S.F. 370.
12. *Coordinate caliper*: Martin type, 300 mm long with millimeter scale (p. 592, f. 271). S.F. 295.
13. *Coordinate caliper*: Aichel type, with millimeter scale (p. 592, "4 a"). S.F. 560.
14. *Attachable goniometer*: Mollison model (pp. 594-596, ff. 273-275). S.F. 170.
15. *Tubular craniophor*: on tripod stand with height adjustment, including skull pincers (p. 593, f. 272). S.F. 260.
16. *Craniophor*: Mollison model (p. 604, f. 281). S.F. 225.
17. *Skull height measuring instrument*: for use with instrument 16 (p. 607, f. 284). S.F. 180.
18. *Combined instruments 16 and 17*: (p. 607, f. 284). S.F. 405.
19. *Cube craniophor*: Schlaginhaufen model with skull pincers but without marble plate (p. 602, f. 280). S.F. 460.
20. *Metal plate skull holder*: used with instrument 19 in place of skull pincers (p. 602, f. 280). S.F. 35.
21. *Sight plane*: Schlaginhaufen model, for use with instrument 19 in determining ear-eye horizon. S.F. 55.
22. *Horizon needle*: 30 cm high (p. 601, f. 279). S.F. 45.
23. *Horizon needle*: as instrument 22, but 45 cm high. S.F. 60.
24. *Dioptrograph*: cube frame of light-metal (instead of wood), for skulls (p. 50, fig. 8). S.F. 1020.
25. *Dioptrograph*: as instrument 24, but large, light-metal frame, for long bones, spinal columns, etc. (p. 51). S.F. 1180.
26. *Diagraph*: with straight drawing arm (p. 54, f. 10 and p. 678, f. 301). S.F. 460.
27. *Parallelograph*: (p. 996, f. 468). S.F. 650.
28. *Bone holder*: for use with instrument 27 (p. 996, f. 468). S.F. 85.
29. *Breast profiles*: according to Lipiec (p. 225). S.F. 120.
30. *Instrument gauge*: for checking calipers (p. 136, f. 58). S.F. 50.
31. *Palatometer*: (p. 600, "12"). S.F. 160.
32. *Orbitometer*: with case (p. 600, "13"). S.F. 40.
33. *Osteometric table*: Ried Model, modified (p. 995, ff. 466 and 467). S.F. 230.
34. *Skin thickness measuring instrument*: (p. 211). S.F. 55.
35. *Mandibulometer*: new construction (p. 597, f. 276). S.F. 380.

These 35 items are listed here in the sequence of the running numbers used by the present Swiss Manufacturers who have succeeded P. Hermann, Rickenbach and Son of Zürich. I have been assured that any or all of these instruments can now be delivered within one month. The same firm is prepared and willing to manufacture upon request additional instruments in accordance to detailed specifications.

## A NEW WEIGHING SCALE

MORRIS STEGGERDA

*Kennedy School of Missions, Hartford Seminary Foundation, Hartford, Conn.*

## TWO FIGURES

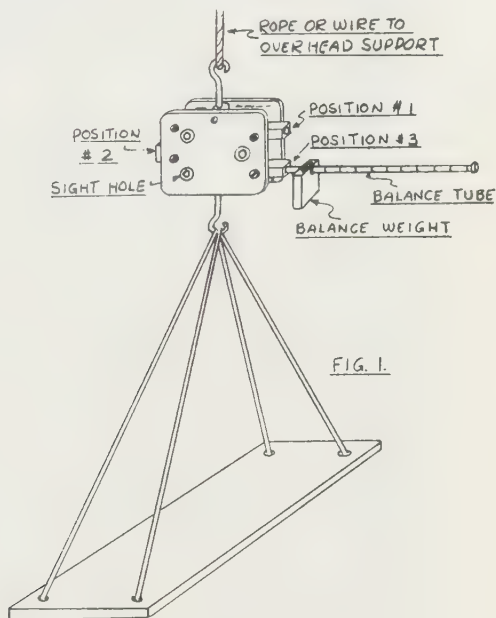
One reason for the dearth of data relative to the weight of mankind is that weighing scales have been difficult to transport. Most field expeditions have left behind the accurate but heavy and cumbersome beam scale. The portable spring "bathroom" scale is too inaccurate for scientific use. Data on human stature and head form has been accumulated from all sections of the earth, but not so for body weight.

Through a grant made by The Viking Fund, I believe we now have a solution to the problem so long troublesome to anthropometrists.

In figure 2 is shown a small, two-pound scale being used to weigh the author. The scale is capable of weighing a man of 325 pounds. It was developed by Lennart Seabeck of Rocky Hill, Connecticut. It is made of aluminum and plated steel so as to prevent corrosion. There are no springs. Each scale is calibrated individually and the parts are concealed so that there is no need of further adjustment. It is shown in detail in figure 1. It was especially designed for convenient use of scientists and field men, and not for commercial use. Its accuracy depends largely upon the skill of the person using it. I have tested a great number of students and found the scale to vary no more than one to one and a half pounds, plus or minus.

I therefore recommend this scale for general use by members of our profession. It is now manufactured and sold by The

Swann Tool and Machine Co., 30 Bartholomew Avenue, Hartford, Connecticut, U. S. A. Full directions for use are supplied with each scale and the price is \$35.00.



	0	1	2	3	4	5	6	7	8	9	10	11	
POSITION #1 - 2	3	4	5	6	7	8	9	10	11	12	13	145	
" #2 - 10	15	20	25	30	35	40	45	50	55	60	65	"	
" #3 - 50	75	100	125	150	175	200	225	250	275	300	325	"	

Fig. 1 Detail drawing of the Seabeck scale.





Fig. 2 Mr. Lennart Seabeck, demonstrating a new weighing scale designed chiefly for field work in Anthropology.

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